The study of Logic, both deductive and inductive, is becoming gradually more and more imperative on account of its world-wide mis-use, the growth of irrationalism and the condemnation of the logical method and principles in the most vulgar way by the most distinguished philosophers of the world. The condemnation of traditional logic as stupid and the identification of inductive inference with physiological inference leading to the abolition of the distinction between human and animal knowledge are some of the outstanding discoveries of our modern philosophers. Yet it is surprising to notice that these great philosophers invariably use the logical method and principles in arrivin This may be my consolation in these days of irrationalism.

In writing out indebted to Mill, Jevons, Bain, Carveth Read, Welton, A. C. Mitra, etc., and have freely borrowed from their books. I am also indebted to my teachers, Rev. A. E. Brown, Dr W. S. Urquhart, and Dr. H. Stephen. May this book be worthy of their instruction.

I have tried my best to make the logical problems easier to the students for whom this book is intended. Every effort has been made to make the book in all respects useful.

The 23rd June, 1937
Monghyr.

CHAPTER IV.

The Law of Causation.

CHAPTER V.

THE MATERIAL GROUNDS OF INDUCTION. OBSERVATION AND EXPERIMENT.

CHAPTER VI.

HYPOTHESIS.

CHAPTER VII.

The Experimental Methods.

CHAPTER VIII.

Analogy.

CHAPTER IX

The Deductive Methods.

CHAPTER X

CHANCE AND THE DOCTRINE OF PROBABILITY.

CHAPTER XI.

DEMONSTRATION AND NECESSARY TRUTH.

CHAPTER XII

ENPLANATION.

CHAPTER XIII

CLASSIFICATION.

CHAPTER XIV

CHAPTER XV

Terminology and Nomenclature.

CHAPTER XVI

Laws of Nature.

CHAPTER XVII

Inductive Fallacies.

INDUCTION

CHAPTER I

INTRODUCTION

1. **Transition to Induction.** We have seen already (vide Text-book of Deductive Logic) that Deduction aims at formal truth and Induction aims at material truth. The problem of Deduction consists in the acceptance of certain premises as true, and then enquiring into what other propositions or conclusions we are consistently bound to accept as true. So in Deduction the conclusion is shown to follow from the premises, and we are not required to see whether the premises and the conclusion are in harmony with the facts of our experience. If the premises be materially true and the reasoning be correct then the conclusion will be materially true. When this is not the case we cannot rely on a deductive argument. Hence in order to make deductive arguments reliable we require materially valid premises.

When the premise is a particular proposition its material validity can be tested by observation, but when it is a universal proposition its validity cannot be tested by observation or experience because such a universal premise implies practically an infinite number of particular facts occurring in the past,

present, and the future which none can experience. We cannot experience 'all men', 'all crows' and 'all apples' and so by experience we cannot test the material validity of 'All men are mortal', 'All crows are black', and 'All apples fall to the ground when unsupported'. To establish the material validity of such universal propositions we require a different process of reasoning which is known as Induction. Every syllogistic reasoning must have a universal premise, and an enquiry into the material validity of this universal premise, without which the syllogism becomes unreliable, leads us naturally to Induction. Thus Induction is a process of reasoning which establishes univesral real propositions. But all universal propositions do not come within the scope of Induction. The axioms are self-evident propositions which cannot be proved by any inference. Definitions and propositions with a property, which is not causally produced,as the predicate are arrived at by analysing the content of the subject term. These also require no inductive proof. Thus Induction is concerned with the discovery and proof of those universal real propositions which have for their predicate accidents. and those propriums which are causally produced.

Every reasoning involves a principle and its application to a particular case. Induction discovers and proves most of these principles and Deduction applies them to particular cases. Thus Induction naturally precedes Deduction and presupposes it. But historically the case is just the opposite. Previously people had implicit faith on their leaders and

religion, and authority was their watchword. They cared more for the application of the principles than for their discovery and proof. So their Logic was deductive. But now, in the days of science, our watchword is experience and so we give more importance to induction and generalisation from experience. But in no stage of our life we can have one of these two kinds of reasoning apart from the other. If one of them is in the foreground, the other is in the background. Both are equally necessary for the operations of the human understanding in the pursuit of truth and for preserving and developing our lives by adjusting us to the changing circumstances in the midst of which we live, move, and have our being.

2. **The Nature of Induction.** Induction is a logical process of reasoning by which we establish a universal real proposition from some particular propositions presented to us by observation or experiment, according to the uniformity of nature and the law of causation. As for instance in the argument: Ram is mortal, Jadu is mortal, Mohan is mortal, etc., and therefore, All men are mortal, we pass from some particular propositions (more correctly singular propositions) to the universal proposition, 'All men are mortal' according to some logical rules and principles, viz., The Uniformity of Nature and the Law of Causation. Thus we see that in Induction we pass from some known data to something which covers within it this known region as well as a vast unknown region; as for instance, in the previous example the morality of only a few human beings has been exami-

ned, while the conclusion 'All men are mortal' comprises within it mankind at large, i. e., men that were, men that are and men that will be. Every induction must take this hazarduous leap from the known to the unknown. There are some reasonings in which we pass from some particular propositions to a universal conclusion but in which there is no such hazarduous leap from the known to the unknown. e. g., after examining all the benches of a class and finding that every one of them is made of wood. we can infer that all the benches of that class are made of wood. Our reasoning here no doubt proceeds from particular instances to all instances of the same kind, yet it cannot be called induction as the conclusion does not cover any new or unknown instance, i. e., is not more general than the premises. Such a kind of reasoning is nothing but a summation of particulars and is called Perfect Induction.

In Conception also we proceed from cases observed by us to an idea of a class comprising within it the cases observed by us and a vast number of unknown and unobserved cases forming the class, by means of analysis, comparison, abstraction, synthesis, and generalisation. But conception cannot be called Induction for it establishes notions or ideas of classes but no proposition or relation between notions. In almost all conceptions we gather a number of attributes in one whole, and the relation between them is tacitly assumed without enquiring how one attribute rises out of another. While in Induction our problem is to show how an attribute gives rise to

another, i. e., causes another, and to make a generalisation on the strength of this causal relation. Thus the relation between one attribute and another is required to be proved in Induction, while in Conception we simply assume this relation between attributes simply because we find them co-existing, i. e., existing simultaneously in the objects observed by us. As for instance in forming the concept *man* we are to observe first of all a number of human beings such as Ram, Shyam, Jadu, Madhu, etc., and then by analysis, comparison, and abstraction we get from them the attributes animality and rationality, and then by integrating them into one whole we generalise them, i. e., maintain that these are the common essential attributes of all human beings. The idea thus formed of the entire class of human beings with the attributes animality and rationality is called a notion or concept. Thus we notice that in this process we do not enquire how rationality rises out of animality or how they have come to co-exist in human beings which is the essential problem of Induction. Thus Conception is widely different from Induction.

Inductive generalisation is always grounded on the law of causation.

Induction is different from many other cases of generalisation such as Induction by Simple Enumeration in which on the strength of repeated similar experience or uncontradicted experience we establish a universal real proposition, e. g., finding a large number of crows to be black we infer that all crows are black. In such an argument we no doubt pass from some cases to all cases yet we cannot call it

Generalisation by simple enumeration is not induction as it is not grounded on the law of causation.

Induction proper, for here also the relation between blackness and the nature of crows is not the matter of proof, i. e., we do not show in it how blackness rises out of the nature of crows ; in other words we do not base such an argument on the Law of Causation which is one of the most essential requirements of Induction. The essence of Induction no doubt lies in the leap or hazard involved in passing from the known to the unknown but we should remember that unless such a leap or hazard is warranted by the Law of Causation it cannot be Induction.

Induction, unlike deduction, establishes material truths or conclusions which are in harmony with facts, while deduction aims at formal truth only. For this reason the premises in deduction can be assumed, while we must on no account assume any one of the premises in Induction—we must get every one of them by observation or experiment if possible ; for the truth of the conclusion depends on the truth of the premises, and so we cannot expect to have materially true conclusions when the premises are assumed. Besides we know that in deduction we proceed from all cases to some cases and that it is a fallacy to go beyond the premises, while in Induction we proceed from some cases to all cases and it is a fallacy not to go beyond the premises. In other words, in deduction our conclusion can never be more general than the premises while in induction our conclusion must be more general than the premises. Inspite of these differences between induction and deduction we shall see later on that induction is not

free from a considerable amount of deductive element.

Another point to be noted in connection with the marks of induction is that it establishes a universal real proposition and not a verbal proposition, and not even a proposition with an ordinary proprium as its predicate term. Verbal propositions and real propositions with an ordinary proprium as their predicate terms are established deductively. Again we should notice that induction establishes universal propositions as opposed to particular ones which are proved by deduction, and in many cases by experience and not by inference. In some cases a law established by induction is extended by means of deduction to a particular instance and thereby we acquire some knowledge of that particular instance, as for example, we often extend the law that all men are mortal to a particular living man and thereby know that he too is mortal. In other cases we observe directly with the help of our various sense organs different particular objects and phenomena and thereby acquire knowledge of them. Thus induction is concerned with the proof of universal real propositions or the laws of nature. These universal real propositions have been called by Kant synthetic judgments *aposteriori* and these really add to our knowledge and give us new information regarding facts and phenomena.

It should also be noticed that induction cannot prove any necessary truth or demonstrative certainty because in it we proceed from some cases to all cases,

i. e., from the known to the unknown. We can have inferential demonstrative truth only when the premises are axiomatic propositions and the reasoning is deductive, as in Geometry. For this reason we cannot be absolutely certain of the validity of our inductive conclusion. There must always remain some amount of doubt in it however little that amount may be. We know by induction that water rusts iron, but in course of time such iron may be manufactured as will remain rustless even when exposed to water. Thus we cannot be absolutely sure that water will always rust iron. But there is no doubt that by induction we can establish rational certainty for it is based on some sure principles and materially true data, and so we can reasonably expect that our conclusion in induction is also materially true. Thus induction establishes rational certainty and not absolute certainty. By induction we know that all men are mortal, clapping is always followed by sound, and many other propositions which are grounded on the law of causation. The certainty of these propositions is hardly inferior to the propositions which are known to be absolutely true. The practical utility of the propositions proved by induction is considerably greater than the propositions about which we are said to be absolutely sure.

For a long time induction was identified with Simple Enumerative Induction which establishes only unreliable conclusions. So medieval logicians discredited Induction and placed their reliance wholly on Deduction. But on account of the association of

Induction with the Law of Causation it has now come to be recognised as the most important form of inferential reasoning. The great advance of the positive sciences is due to the application of the modern form of induction.

3. **The Inductive Process.** How we are to establish a materially true, universal real proposition is the problem of induction ; in other words we try to establish by means of induction **the laws of nature.** We shall see later on that such a law or universal real proposition can be established only when we are able to detect a causal relation between two phenomena. Thus the problem of induction is equivalent to the problem of finding out causal relations between phenomena. Now let us see how we actually proceed in induction in order to establish such a causal relation, and through it and by means of it, a universal real proposition. Suppose we are required to find out the cause of malaria. Now how are we to proceed to find out its cause ?

The first thing necessary for us will be **observation**, i. e., we must observe, first of all, a large number of instances of the phenomenon about which we want to make a generalisation, detect a causal relation and establish a law or universal real proposition. This observation should be made carefully, patiently, thoroughly, and methodically. Bias, prejudice or preconceived opinion should in no way influence our observation. We should also carefully record all the things observed by us. Now observation is necessary for getting accurate premises for the inductive

generalisation without which no induction is possible. Thus observation lies at the foundation of the inductive procedure. Hence the first thing to be done in finding out the cause of malaria is to observe a good many cases of malaria carefully, patiently and thoroughly and take notice of the circumstances in the midst of which malaria takes place. Modern logicians however do not place so much importance on the examination of a large number of facts. De Morgan says, "Modern discoveries have not been made by large collections of facts with subsequent discussion, separation and resulting deduction of a truth thus rendered perceptible. A few facts have suggested an hypothesis, which means a supposition proper to explain them. The necessary results of this supposition are worked out, and then, not till then, other facts are examined to see if these ulterior results are found in nature." But this is possible on account of the advancement of learning and the accumulation of much scientific knowledge. Great difficulty is felt in the inductive investigation owing to the fact that circumstances conceal the causes, e. g., the flower producing a particular scent is hidden by other flowers of the garden, and the phenomenon studied is distored by disturbing circumstances, e. g., the motion of a feather is distored by air.

Next we should **analyse** the particular instances observed by us into their attributes, activities, and attendant circumstances. This analysis may be done mentally or physically. In other words we may view

in our mind the attributes and conditions of the particular instances separately, i. e., we may draw a distinction between them, or we may physically isolate the different attributes, activities and condidions. Mental analysis of the object is known as *resolution* while physical analysis or isolation is known as *elimination.* For elimination we generally require experiment. Most of the events or phenomena of this world are so complex in nature that we fail to understand them properly when we are unable to analyse them into their elements. Thus where analysis is impossible induction is also impossible. The purpose of analysis is to create a kind of void around the phenomenon under investigation so that it may stand out naked and clear of the details in which it is embedded and which are irrelevant to it. When these details are isolated the universal element on which the particular phenomenon under investigation depends becomes apparent. (Int. Logic, Welton and Monhan-p. 273). In the case of malaria we are to analyse the different cases of malaria observed by us, into their various symptoms, i. e., attributes and activities, and also analyse the circumstances in the midst of which malaria takes place.

After analysis we are to **define** carefully the phenomenon under investigation and thereby distinguish it from similar other phenomena. And so in order to find out the cause of malaria we must define it carefully by means of the essential symptoms ascertained by observation and analysis. This

definition of the phenomenon under investigation is essentially needed in order to have a definite and accurate knowledge of it and to distinguish it from other similar phenomena. As in the case of malaria if we fail to define it by means of its essential symptoms there is every possibility of our confusing malaria with other cases of fever, and thereby making the problem of finding out the cause of malaria very difficult, if not impossible.

In a definition we are to state the common essential attributes of the objects defined, and by analysis alone we can get these common essential attributes. So definition necessarily comes after analysis and is possible after analysis.

After defining the phenomenon under investigation we are required to frame a **hypothesis** as to the cause of the phenomenon, i. e., we are to suppose that some of the conditions in the midst of which the phenomenon takes place is its cause. This hypothesis is often made at the very beginning of an inductive investigation, and in the light of this hypothesis, observation is made. But such hypotheses are not reliable, e. g., when influenza broke out in England people supposed that it was due to a deluge in China or a volcanic erruption in Java. Reliable and scientific hypothesis can be made only after careful observation, analysis, and definition. In the case of malaria we suppose that mosquito biting is the cause of malaria. We may make other suppositions no doubt, viz., marsh gas, foul water, etc.; but in view of the scientific researches with which we are acquainted to

some extent mosquito biting seems to be the most reasonable one.

The next thing necessary in the inductive procedure is the **proof of our hypothesis.** Now if there are more than one hypothesis we must eliminate the rival hypotheses by means of the *crucial instances* and the *experimentum crucis*, i. e., we must get instances of the phenomenon in question either by means of observation or experiment which can be explained only by our hypothesis and not by any other. As in the case of malaria we can easily show that people living near marshy place and using mosquito curtains do not suffer from malaria. Hence marsh gas cannot be the cause of malaria.

After eliminating the rival hypotheses we must prove our hypothesis by the experimental methods. This has been described by Carveth Read as the process of varying the circumstances, because the application of the Methods depends on such variations. We should try to prove it by the Method of Difference which is the most reliable method. If we fail to do that we must prove the hypothesis by the Joint Method. Failing which our hypothesis will remain probable. The purpose of these methods is to show that whenever the supposed cause is present the phenomenon under investigation is present, and whenever the supposed cause is absent the phenomenon is also absent. In the case of malaria we must show by these methods that where mosquitos are present malaria is present and where they are absent malaria is also absent.

Finally we make fresh observation in order to verify our hypothesis. If our hypothesis be in harmony with all the facts observed it will be accepted as true. but it will be either modified or rejected if we find any inconsistency between our hypothesis and the fresh facts observed by us. Even after the proof of a hypothesis by the experimental methods the possibility of inconsistency between the hypothesis and fresh facts remains because in proving it we use premises which either do not contain some relevant conditions, or contain some which are not in any way relevant, i. e., our investigation is vitiated by non-observation and mal-observation. Thus when a hypothesis is proved by the experimental methods and stands the test of verification it becomes established as a natural law or a universal real proposition and is accepted as true, and the inductive procedure comes to an end.

Here we have considered the hypothetical method. But when we are required to find out the effect of a cause we resort to experiment if it is under our control and is not too dangerous. When it is beyond our control or too dangerous we resort to deduction nd verification by means of observation.

4. **The Problem of Induction**. It has already been pointed out that the problem of induction is generalisation through the medium of the causal connection, because rational and reliable generalisation is possible only when it is grounded on the law of causation. Every generalisation refers to a relation to be generalized. Now there

are three kinds of relation in the world, viz., (1) the relation of co-existence, (2) the relation of succession, and (3) the relation of equality or inequality. Generalisation is possible with regard to any one of these relations. As for instance, "A co-exists with B" may be generalised into—"In all cases A co-exists with B." Similarly we find that milk co-exists with whiteness and we may generalise it into: 'All cases of milk are cases of whiteness or milk is always white.' We know that sound follows clapping which may be generalised into: All cases of clapping are followed by sound. Again we find by measurement that in twenty cases of triangles the three interior angles are together equal to two right angles and from this we may infer that in all cases of triangles the interior angles are together equal to two right angles. Similarly 'in all cases any two sides of a triangle are together greater than the third,' is a generalised relation of inequality. Thus generalisation may be one of co-existence, succession, equality or inequality.

Now let us see which kind of generalisation forms the subject matter of induction. Is it concerned with the generalisation of the relations of co-existence? So far as these relations are not grounded on the law of causation they cannot be the subject matter of induction. In a case of co-existence we cannot ovserve how one of the co-existing factors rises out of the other, and so the relation between them cannot be proved. Hence we cannot be sure whether the two factors are bound together by an

inseparable essential relation. Hence the relations of co-existence are ordinarily excluded from the scope of the inductive investigation. But there are many relations of co-existence which are found to rest on and arise out of some causal basis. Such relations are included within the scope of induction. Heat and light are found to co-exist in the rays of the sun as they are simultaneously produced by these rays, and so their relation falls within the scope of Induction.

Now let us examine whether the relations of succession are included within the scope of induction. In succession we notice that there are two factors of which one happens immediately after the happening of the other. Now a relation of succession may be either *variable* or *invariable*. We find that happiness follows marriage in some cases and does not follow it in other cases. Hence the succession between marriage and happiness is a case of variable succession. Such a relation does not illustrate uniformity or universality, which is the subject matter of induction. But indirectly we are concerned with it in induction, for we shall see later on that in induction we can establish a causal relation by excluding all sorts of variable succession. But the real subject matter of induction is invariable succession due to causation. We shall find later on that the cause is an invariable, unconditional, and immediate antecedent of an event called its effect and is quantitativelty equal to it. Thus there is a relation of invariable sequence between the cause

and its effect. Therefore induction is concerned with the relations of invariable succession due to causation.

But there are some cases of invariable succession which are not grounded on the causal relation, *e. g.*, Monday invariably follows Sunday, yet the latter is not the cause of the former. Thus the generalisations of the relations of invariable succession on the strength of the causal relations form the subject matter of induction. We should notice here that in the inductive problem there are two factors, viz., (1) the detection of the causal relation and (2) the generalisation of this causal relation. Of these two factors the second is very easy but the first one is very difficult. Even a child can generalise when the causal relation is detected. Therefore in induction we leave aside generalisation, and devote all our attention to the problem of finding out the causal relation.

The third kind of relation giving rise to generalisation is the relation of equality or inequality. These quantitative generalisations generally come within the scope of mathematics, which is a deductive science of quantity, and not within induction. Besides these quantitative relations do not show how one quantity rises out of another—they rather illustrate co-existence, and so we fail to detect in them any causal relation. But quantitative relations are not wholly outside the scope of induction, for we know that quantitatively the cause is equal to the effect, i.e., the quantity of energy in the

cause is equal to the quantity of energy in the effect: in other words, the energy in the cause becomes transformed into its effect. Thus to establish a causal relation we must prove the quantitative equivalence between the supposed cause and its effect or the transference of energy from the cause to its effect. Thus quantitative generalisations are not wholly excluded from induction.

We thus conclude that the problem of induction is to detect causal relation between phenomena. Now a phenomenon may be given and we may be asked to find out its effect, or we may be required to find out its cause. Thus we may proceed either from the cause to its effect or we may proceed from the effect to the cause. The problem of finding out the effect of a given phenomenon is successfully solved by means of experiment. But there are many cases where the agents are beyond our control, *e. g.*, the sun-spots, and also cases which are too dangerous to experiment with, *e. g.*, a new legislation. In such cases we deduce conclusions from the thing in question and verify these conclusions by subsequent observation. But experiment does not help us when we proceed from the effect to the cause for by no means we can move from the actual effect to its actual cause, *i. e.*, from the present to the past for the cause in relation to the effect is a matter of the past and cannot be recovered either by nature or by magic. Hence in finding out the cause from the effect we are to depend on observation and hypothesis, *i. e.*, we are to suppose certain phenomenon to

be the cause in question and then by means of the crucial instances, the experimental methods, and verification we are to prove this hypothesis. Thus in induction we proceed in one direction, viz., from the cause real or supposed, to its effect. (C. Read).

5. **The Relation between Induction and Deduction.** In deduction we argue from a universal proposition to a particular or less general proposition. As for example in the argument: 'All men are mortal, Ram is a man, therefore Ram is mortal,' we start from the universal proposition, 'All men are mortal' and arrive at the singular proposition, 'Ram is mortal' by means of deduction, i.e., we proceed from the mortality of all human beings to the mortality of a particular instance of man, viz., Ram. We find that in the argument there are two premises only of which one is universal and the other singular. We know also that in every syllogistic reasoning which is considered to be the model of deductive reasoning there must be at least one universal premise as from two particular premises no conclusion can be drawn. Now the question is how we get this universal proposition. We cannot get it by observation or experiment, i.e., experience, for experience gives us only particular truths. We can get it by deduction but that deduction will require another universal proposition, and the same question will arise as to that universal proposition. Thus the question becomes simply shifted from one universal to another universal. Therefore deduction cannot give us any

real universal proposition to be used as a premise in a deductive reasoning. By means of deduction we can have universal propositions deduced from axiomatic propositions. But these propositions are verbal or deductions from verbal propositions Excluding all such propositions it can be said that by deduction we cannot arrive at the universal propositions which are ordinarily used in our daily life. In a formal deductive reasoning we generally assume these universal propositions, and so we cannot be sure of the conclusions drawn from them. Consequently these conclusions become practically useless. In order to have practically useful deduction our premises must be materially true, and when they are not axiomatic the universal ones must be grounded on induction. Thus an examination of the material validity of the conclusion naturally leads us to induction, and conclusively points out that deduction depends on induction.

Now let us examine this same relation from the standpoint of induction. We have seen already that in it, on the strength of the law of causation we arrive at a universal real proposition from some particular instances of a phenomenon observed by us. Thus induction is based on the law of causation (Every event has a cause) which embraces within it the uniformity of nature (The same cause produces the same effect), and the inductive conclusion may be said to be deduced from that law. Thus induction is based on deduction. Besides in scientific induction we are required to frame hypotheses

and to verify them. When they are verified they become induction. But the process of verification is an extension of a law to a particular case and is, therefore, deductive in nature. Thus every scientific induction is based on deduction as it requires the help of verification which is a deductive process. Thus it is clear that induction and deduction are interdependent, and one presupposes the other.

Ignoring the relation of interdependence between induction and deduction many logicians have asked the question which one of these two forms of reasoning is the fundamental one, and which one comes first or precedes the other. The logicians of the nominalistic school maintain that the fundamental form of reasoning is from some particulars to a particular, i.e., a form of reasoning which is neither deductive nor inductive. As for instance, after examining ten mangoes and finding them to be sweet we infer that the eleventh mango is also sweet. In such cases the universal proposition is not developed and clearly stated, but all the same, it is there within our mind in a suppressed state, for unless we neglect the individual peculiarities of the particular instances and fix our attention on their essential nature it is not possible for us to pass from some particulars to a new particular. Besides such an argument can never give us the certainty of induction. Hence such a reasoning cannot be called the fundamental reasoning.

J. S. Mill holds that induction precedes deduction and that deduction is only a disguised form of

induction as it simply extends a general law established by induction to some particular cognate cases. This view is psychologically true. Little children cannot be expected to be acquainted with the laws or universal propositions which are necessary for deduction. They perceive particular facts and generalise them into laws and then extend these laws to fresh instances. Hence we find that induction comes first and then comes deduction, and consequently induction is the most fundamental form of reasoning.

But the **realists** maintain that the fundamental form of reasoning is deductive, i.e., from the universal to the particular, for all reasoning supposes some principles or axioms, e.g., the laws of thought, the uniformity of nature, etc., without which thinking becomes wholly impossible. By making these laws and their corollaries, e. g., the experimental methods, our major premise, and the particular instances satisfying the requirements of these laws and corollaries as our minor premise, the inductive argument can be transformed into a syllogistic argument. Thus it seems that induction is a disguised form of deduction. Hence deduction precedes induction and is the most fundamental form of reasoning. It may be pointed out in this connection that **Jevons** maintains that deduction precedes induction because induction involves hypothesis and verification, and it has already been pointed out that verification is a deductive process.

6. The Inductive Syllogism. Bearing in mind the truth of the arguments advanced by the

realists great logicians from the time of **Aristotle** have tried to reduce the inductive arguments into syllogistic ones and have regarded such arguments as the inductive syllogism. Arsitotle himself reduced an inductive argument to a syllogism of the third figure and described the form of reasoning as "proving the major term of the middle by means of the minor", e g.,

Ram, Shyam, Jadu, Madhu and others are mortal.
Ram, Shyam, Jadu, Madhu and others are all men.
∴ All men are mortal.

Here Aristotle means by the major term, the term of the greatest denotation, viz., mortal, and by the minor term he means the term of the lowest denotation, viz., Ram, Shyam, Jadu, Madhu and others, and by the middle term he means the term of the middle or intermediate denotation, viz., all men. Thus the syllogism proves the major term, mortal, of the middle term, all men, by camparing them with the minor, viz., Ram, Shyam, Jadu, Madhu, and others. Hence Aristotle has not used the terms, major, minor, and middle, in the sense in which they are used in logic.

Now this attempt of Aristotle is futile for how does he get the major premise? He has not examined any and every individual man for that is physically impossible. He can examine only a few men. But by examining some cases only it cannot be said that all other cases will possess the same characteristic, viz., mortality, without the help of induction. So we find that Aristotle simply assumes the conclusion in

the major premise without proving it. But if somebody takes the absurd position and maintains that all the cases of men were examined and on the strength of that examination the major premise was laid down, it can be said in reply that in that case the argument will not involve a leap from the known to the unknown which every true induction does, and will establish a conclusion which is nothing but a summation of all the particular instances observed. Thus we see that a true inductive argument which involves a passage from the known to the unknown, and from some to all cases cannot be expressed in the form of a syllogism as given by Aristotle. Here the error does not lie in the minor premise which may be granted as true. The real error lies in the major premise which directly assumes that the other men whom I have not examined are also mortal. Besides the copula **are** in the minor premise means constitutes which is clear from the quantification of the predicate. Hence the subject of the minor premise has been taken collectively, while it has been used distributively in the major premise. Hence, in the argument there is a passage from the distributive use of the middle term to its collective use and so the syllogism involves the fallacy of composition.

Aldrich and **Whately** reduced induction to a syllogism of the first figure in the following way :—

The men whom I have observed and the men whom I have not observed are mortal.

All men are the men whom I have observed and the men whom I have not observed.

∴ All men are mortal.

Here also we find that the major premise has either been unduly assumed or there has been no passage from the known to the unknown. Aldrich and Whately have no justification in saying that the men whom I have not observed are mortal without already taking for granted that all men are mortal. Hence the syllogism involves *petitio principii.* Besides the middle term has been used distributively in the major premise while it has been used collectively in the minor premise. Hence it involves also the falley of composition. Thus we find that this form of syllogism does not truly represent induction.

Carveth Read admits that induction has a great deal of formal element. He writes : "In fact Inductive Logic may be considered as having a purely formal character. It consists first in a statement of the Law of Cause and Effect : secondly, in certain immediate inferences from this Law, expanded into Canons ; thirdly in the syllogistic application of the Canons to special propositions of causation by means of minor premises showing that certain instances satisfy the cannos". As for instance :

Whatever relation has certain marks is a case of Causation. (The Canon of Difference, suppose.)

The relation A : p has all these marks.

∴ The relation A : p is a case of causation.

Again

"If an instance etc. (The Canons of Difference).

The instances ABC/pqr, BC/qr are of the kind required.

∴ A is causally connected with p" (modified)

Thus it appears that the "formal Logic of Induction is essentially deductive". But if we remember that in induction though we use symbols in representing the premises yet in an actual induction we must get them by means of observation or experiment, and the facts gathered from these sources refuse to be represented in the form of the isolated, well-defined symbols. Besides the passage from the known to the unknown and the establishment of material truth are peculiar to induction and can hardly be achieved by means of the syllogistic form of reasoning. A careful analysis of reasoning whether logical or psychological will reveal that one form of this reasoning depends on the other. Hence it is not correct to maintain that one is prior to the other or that one is more fundamental than the other.

7. **Induction as the Converse of Deduction.** Now let us consider whether inducton is the **converse of deduction** and whether it can be regarded also as the **inverse of deduction.** According to Jevons induction is the inverse process of deduction. "As generally stated deduction consists in passing from more general to less general truths; induction is the contrary process from less to more general truths. We may however describe the difference in another manner. In deduction we are engaged in developing the consequences of a law. We learn the meaning, contents, results or inferences, which attach to any given proposition. Induction is the exactly inverse process. Given certain results or consequences, we are required to discover the general

law from which they follow" (*Principles of Science* p 11). This is according to some writers the converse process of deduction. In conversion we know that the converse has for its subject and predicate, the predicate and the subject of the premise or the convertend. Now in deduction we proceed from the universal to the particular or the less general on the strength of the law of identity, while in induction we proceed from the particulars to the universal or a law on the strength of the law of causation. Hence to a certain extent the processes are the converse of each other. But it has been pointed out that the one rests on the law of identity while the other on the law of causation. Causation is not simply identity, it is more than that. Besides in one we are concerned with facts and material truths and a vision into the unknown and the future while in the other we are concerned with the implication of a universal proposition or law, i. e., the specification of its contents without any reference to facts or material truths. Therefore though we utilise the deductive form of reasoning in verifying our hypothesis yet induction cannot be regarded as exactly the converse of deduction. Bacon's description of induction as an **ascending process** and deduction as the **descending process** implies this converse nature of induction. But this description is too much figurative to be of any scientific value.

8. **Induction as the Inverse process.** In Deduction we directly start with a fully formed, ready made law and then extend this law to particular

facts or phenomena and thereby explain them. Now in induction we also aim at explaining these facts and phenomena. But instead of directly starting with laws (for about the validity of these laws we are not sure), we start with the particular facts gathered by means of observation or experiment. and then establish a law methodically, and then extend this law to the facts or phenomena to be explained. But if we fail to apply the logical Methods directly to the facts observed on account of their complexity then we form a hypothesis and then verify it by extending it to the facts in question by means of deduction, and when a hypothesis is verified it is accepted as a law or induction, and the facts are said to be explained. Thus in induction we proceed from facts to laws established or supposed and then from these laws we pass on to the facts to be explained. While in deduction we directly deduce the facts to be explained from some established law or laws. Hence induction is regarded as the inverse form of deduction. But we shall remember that this is not the whole truth, for by no means formal truth can be changed into material truth, and the unknown, the distant and the future can be transformed into the known. Deduction does not take into consideration how one thing or event is brought into existance or produced by another. Hence by inverting Deduction we cannot have induction. It has already been pointed out that induction and deduction are interdependent and one cannot be had apart from the other.

'Inverse' is a mathematical term and opposed to the word, direct. In the direct method the conclusion is deductively inferred from the data, e. g., from **3 × 4** we get **12.** Here we are absolutely sure of the conclusion. But in the inverse method the conclusion is given and we are required to ascertain the data from which it has been arrived at. Such a process is precarious and so unreliable, as for instance from **12** it is difficult to arrive at **3 × 4** for what is the guarantee that this **12** is not the outcome of **6 × 2** or **24 ÷ 2** or **20 − 8.** Thus induction as the inverse of deduction implies two things viz. (1) in induction we proceed from facts to causes and conditions producing them, and (2) that the inductive conclusions are uncertain. **Welton** almost subscribes to the same view when he says: "In induction, reality presents itself in concrete and partially isolated instances, and the task of inference is to discern the universal which is more or less hidden in those instances." In deduction on the other hand reality presents itself in its universal aspect and the task of inference is to trace the presence of that universal in the differing and complex instances of its manifestation. (*Manual* ii p 61.) But the indefiniteness of the inductive argument disappears on account of the causal principle which implies that an event can be produced by one and the same cause. Hence the description of the Induction as the inverse process of deduction is misleading and vague.

9. **The value or the utility of Induction.**

Why do we reason inductively? We live in the midst of a bewildering mass of diverse facts and phenomena, and a knowledge of these is essentially necessary for the preservation and development of our life. Besides we are required continually to adjust ourselves to the ever changing circumstances, and without a knowledge of these circumstances it is hopelessly impossible for us to adjust ourselves to them. Now induction is necessary because it gives us a knowledge of this bewildering mass of diverse events and the changing circumstances in the midst of which we live, move, and have our being. Such a knowledge gives us mastery over these events and circumstances, and enables us to adjust ourselves to them. Induction establishes the laws of nature which are nothing but the uniform behaviour of classes of facts and events. With the help of these laws we know beforehand how these facts and events will behave in future. Thus induction gives us a knowledge of the future events which materially helps us in preserving and developing our life.

Experience reveals to us a chaotic mass of diverse facts and phenomena, and Induction determines their laws of operation which are called the laws of nature. With the help of these laws we understand the bewildering mass of events, and systematise them into a well-ordered world or cosmos. When facts are systematised or well arranged and bound by definite principles they can be remembered whenever necessary and their knowledge can be utilised in future in vestigation. Thus induction is useful in

ascertaining the harmony of the apparently diverse world, and in ascertaining and reading the facts of nature. It is therefore a great aid to memory, and so it helps future investigation.

The positive sciences apply the inductive method and principles to the different departments of the world. So induction is said to be the basis, introduction or prolegomena to the positive sciences. The tremendous development of the modern sciences emphatically points out the great ultility of induction. The more the development of the positive sciences the more will be the achievement of induction.

Induction gives us a kind of knowledge and so its utility is identical with that of knowledge. Every human being has to argue inductively but every one's argument is not valid. So induction comes in to tell us how to advance correct inductive argument.

It has already been pointed out that the universal real propositions which are generally used as the premises of deductive reasoning are supplied by induction. Deduction also helps induction in verifying the inductive hypotheses and deducing them from the law of causation and the Methods derived from them. Thus induction and deduction run into each other and both the processes are equally useful.

But there are logicians who hold extreme views no the subject. As for instance according to Hamilton, Mansel, and Dr. P. K. Ray there is only one

kind of argument, viz., deductive, and induction apart from deduction can be hardly called reasoning. Whereas Mill maintains that the only form of reasoning is inductive, deduction is not only useless but also fallacious, for in laying down the universal major premise all inference is exhausted leaving no further room for deductive argument.Both these views are half truths because in the scientific induction both the deductive and the inductive elements are present. Hence there cannot be any induction without deduction. Thus both these processes are eqaully necessary and both are supplementary to each other.

Induction and Deduction are interdependent and are supplementary to each other.

10. **Development of Induction and its Recognition as a Legitimate form of Inference.** In an elementary book like this proper justice cannot be done to this topic though it is greatly interesting and instructive. This subject properly belongs to the history of Logic and not to Logic proper.

History of Induction.

In the middle age, i. e., before the time of Elizabeth, induction was not recognised as a proper form of reasoning and by Logic every one meant Deductive Logic. The study of deduction was confined to the church fathers or clergymen. Thus Logic was treated almost as a holy or divine subject, and lay-men were hardly allowed to study Logic. Along with Philosophy Logic was the hand-maid of religion. So in such an age the study of induction was hopelessly impossible. The great credit of Bacon lies in the fact that he brought Logic and Philosophy from the confines of the church-walls and allowed

In the middle age Induction was not treated as a legitimate form of inference.

both of them to breathe fresh air and start a new life. So there is every justification for treating Bacon as the father of Inductive Philosophy.

The inductive form of argument is so very intimately connected with the human understanding that we cannot conceive of any time when mankind did not advance this form of reasoning. But the definite recognition of it as a legitimate form of reasoning is a different thing altogether. Whether Aristotle and the Scholastic logicians actually employed this inductive method in their writings is a matter of historical research. But this much is certain that they did not recognise induction as a legitimate method of inferential reasoning. To them deduction was the ideal method of reasoning and so they tried to test every form of reasoning by the syllogistic rules. The Inductive syllogism of Aristotle, his proof from experience, and the Scholastic Perfect and Imperfect Induction are widely different from modern Induction. The reliability of modern induction is due to its association with the law of causation, while the pre-Baconian Induction rested simply on the number of facts examined, i. e., on enumeration, and had nothing to do with the law of causation. Hence the pre-Baconian induction was unreliable.

Nature of Baconian Induction: According to Bacon deductive Logic as formulated by Aristotle and adopted by the Scholsatic logicians is completely useless. The only useful logic is induction. So he calls his inductive method *Novum Organon* or new logic as opposed to the Organon of

Aristotle. He condemns also the Simple Enumerative Induction as purile and uncertain because the possibility of being frustrated by a contradictory instance is not eliminated in such a reasoning. The right method of acquiring knowledge is not to anticipate nature, not to form any guess, supposition or hypothesis but to go to nature herself and interrogate her, torture her, just as an advocate tortures a witness at the time of cross examining him, and thereby compel nature to yield and reveal her truths and mysteries. Thus Bacon is opposed to the formation of hypothesis which plays a very important part in the modern inductive investigation. We must study the facts and phenomena first of all, after getting rid of all pre-conceived notions, and it is by interpreting these facts or phenomena that knowledge can be acquired. After collecting these facts and phenomena which constitute the raw material of knowledge we should try to find out the "**forms**" of these facts and phenomena gradually. By forms he means either the causes of things or their essence. Hence according to Bacon we should at first gather facts and phenomena and then generalise them into minor laws and these laws into higher and higher laws till the highest law is arrived at. He also advises us to analyse the things of our experience into properties and accidents, and the essential properties that make a thing what it is are called forms.

Now Bacon lays down certain methods or tables for abstracting and isolating the forms of things.

(a) The **table of affirmatives** according to which we are to take into consideration the positive instances of the phenomenon under investigation. Out of this table Mill's Method of Agreement has been developed.

(b) The **table of negatives** according to which we are to take into consideration the instance in which the phenomenon under investigation does not occur. Out of this Mill's Joint Method has been developed.

(c) The **table of Comparisons or Degrees** according to which we are to take into consideration the various degrees or the quantitative variations of the phenomenon. Out of this Mill's Method of Concomitant Variations has been developed.

Besides these tables Bacon lays down the **method of Exclusion** according to which we are to exclude one by one all the non-causes and thereby find out the real cause of the phenomenon. If for example we know that the csuse of A is X, Y or Z and if we can show that Y and Z are not the causes of A then we can conclude that X is the cause of A. When the possible causes are not exhaustively known the conclusion is bound to be erroneous. Yet this method of exclusion underlies all the modern inductive investigation and the Experimental Methods. The Tables and the Method of Exclusion embody the **Baconian Method of Varying the circumstances** without which the forms or causes cannot be detected.

The greatest defect of Bacon's induction lies in

the fact that according to it hypothesis is rejected as useless, and human understanding is treated as entirely passive. But without the aid of hypothesis and an active mind no inductive investigation can be carried on.

Newton. Newton like Bacon rejected hypothesis but he meant by hypothesis all those premature, assumptions which are made on altogether insufficient grounds. According to Jevons, Newton did not entertain any hypothesis which was not definite in condition and which did not admit of unquestionable deductive reasoning, and which could not be decided by the comparison of its consequences with facts. But Jevons confuses the implications of Newton's method with its accepted meaning. Newton's rejection of hypothesis is emphatic and explicit though he himself formed hypotheses and though his method implies the formation of hypothesis.

Newton's method consists of two things, viz., the **Method of analysis** and **the Method of Composition or Synthesis.** The Method of Analysis consists in making experiments and observation and in drawing general conclusions from them by induction. By this method we proceed from effects to causes and from particular causes to more general ones and so on till the most general one is arrived at. The Method of Composition means deduction from the general law arrived at by the method of analysis followed by the comparison of the consequences with the observed facts, i. e., verification.

Thus Newton recognises both deduction and induction as useful and necessary, and we find that his method contains (a) observation and experiment, (b) induction, (c) deduction from this induction, and (d) verification. From the time of Newton science began to progress rapidly and with its progress induction quickly advanced and came to be recognised as a legitimate method of reasoning.

J. S. Mill. It was Mill who gave the inductive method its modern shape. His credit lies in the explicit formulation of the Experimental Methods, and systematically explaining the whole of the inductive method of investigation together with the explanation of the subsidiary processes. Though modern induction has undergone many changes yet it has remained fundamentally in the state in which Mill left it. Mill has defined induction as the operation of discovering and proving general propositions. According to him we are to gather facts by means of observation and experiment, then we are to arrange them in the light of the experimental Methods, and lastly we are to arrive at a causal relation by applying one of these methods. Thus Mill minimises the value of hypothesis and thinks that the facts can be studied, arranged and the methods can be applied without the help of hypothesis. This is the greatest defect of Mill's logic. His philosophical basis of logic and his explanation of the method of arriving at the fundamental principle of the uniformity of nature are not acceptable now-a-days. Besides Mill places more

importance on the uniformity of nature than on the law of causation, and does not explain the true nature of the uniformity of nature and its relation with the law of causation.

Whewell. It was Whewell who emphatically pointed out the importance of hypothesis without which no induction is possible. He also laid down that without an active manipulation of facts guided by hypothesis no inductive generalisation is possible. With a passive mind nothing can be arrived at by any mechanical process. According to Whewell we should gather facts and colligate them by means of an exact and appropriate conception. This appropriate conception is a hypothesis. In order to accept such a hypothesis as true we must compare it with facts and only after a rigorous comparison with facts we must support it in all its details. If there be any discrepancy between facts and the hypothesis then the hypothesis itself should be rejected or modified. Whewell's blunder lies in neglecting the experimental methods and in identifying induction with the colligation of facts. We shall see later on that every colligation of facts is not induction. Besides the discovery of a concept is not the final step in induction, because a concept becomes truly established when it is proved. But Whewell neglects the proof-side of induction and lays stress on the discovery-side.

Jevons. According to Jevons Induction is essentially enumerative in character so it establishes only probable conclusion. Inductive reasoning

therefore is grounded on the mathematical doctrine of probability. Jevons describes induction as the verse process of deduction and maintains that there cannot be any inductive investigation without the application of some hypothesis. Thus Jevons also agrees with Whewell as to the great importance of hypothesis. But Jevons confuses rational certainty with absolute certainty and so finds reason to denounce all induction as probable. (Welton's Manual pp32-55).

After Jevons, Bain and Carveth Read have done much for the improvement of the method of induction. Thus the claim of induction as a legitimate form of reasoning has been well recognised.

11. Exercises.

1. Explain clearly with the help of an example how we reason inductively.
2. Why do we reason inductively ?
3. How do we reason inductively ?
4. Can induction be dispensed with ?
5. What are the uses of induction ?
6. What are the marks of Induction ?
7. Can any and every generalisation be treated as inductive ? If not, give your reasons.
8. What is the nature of the problem enquired into by Induction ?
9. Show how deduction runs into induction. Are the processes supplementary to each other?
10. Mention some instances of deduction which are fully independent of induction.
11. Explain the relation between deduction and induction.

12. Explain what you understand by Inductive syllogism. Can induction be really reduced to the syllogistic form ?

13. Explain the various attempts that have been made to reduce induction to the syllogistic form. How far were these attempts successful ?

14. Explain : "Proving the major term of the middle by means of the minor."

15. Is modern induction free from deductive element ?

16. Explain "Induction is the converse of Deduction."

17. Explain "Induction is the inverse of Deduction."

18 Discuss the question of the relative priority of deduction and induction.

19. Explain how induction has come to be recognised as a legitimate form of inference.

20. Define Induction and explain what kind of truth is established by it.

21. Explain what you consider the true relation of Deduction and Induction, illustrating your reasoning by examples ; and discuss the claim of Induction to be treated as a separate department of Logic.

22. Induction is the process of establishing general propositions and Deduction is the interpretation of them. Explain and illustrate this. Is this theory of reasoning here implied admitted by all logicians? If not, what other theory has been held.

23. What is meant by a Deductive and what by an Inductive science ? State the principal Deductive and the principal Inductive sciences explaining in the case of each of these sciences why it is called Deductive or Inductive.

24. Mill and Bain think that three operations are implied in the full scope of the Deductive method, namely, Induction, deduction proper, and Verification. Explain the exact meaning of each and exhibit their relation to one another, making your meaning clear by means of examples. Do you consider that Mill and Bain are right in thus holding that all Deductions depend on previous Induction? Give your reasons.

25. Can we form a valid universal proposition about facts if we have not actually observed all the individuals signified by the subject of the proposition? If so, how?

26. Exhibit the nature and use of the Inductive Method.

27. Determine the character of inference and show how it is illustrated in Induction.

28. Can Induction be reduced to syllogistic reasoning? Fully discuss this question examining the different attempts that have been made to resolve the former into the latter.

29. Discuss fully whether Induction precedes Deduction or Deduction precedes Induction.

30. 'The difference between Deduction and Induction is not one of principle but of starting point'. Discuss.

31. Describe the general process of Induction and its aim.

32. Explain how general ideas are formed and how generalisations are made popularly and scientifically? Can there be any generalisation without general ideas?

CHAPTER II

Processes Simulating Induction and Unscientific Induction.

1. **Simulating Induction.** There are certain processes of reasoning which appear to be inductive in nature but are not really so, and for this reason they are called Processes Simulating Induction. We have seen already that a logical Induction must involve generalisation of a relation of succession on the authority of the law of causation, and must imply a passage from the known to the unknown If any one of these marks be wanting the process of reasoning ceases to be logical or scientific induction, and becomes a process simulating induction. It should be borne in mind that originally any generalisation of a case of succession whether grounded on the law of causation or not was treated as true induction. Hence even at the time of Mill the number of the processes simulating induction was every small. But now-a-days scientific induction must be grounded on the law of causation, and so the number of simulating induction is many.

It should be remembered that though these processes fall short of the ideal form of inductive reasoning yet they are not useless. Such processes establish various degrees of probability which are

extremely valuable in the practical affairs of life. They suggest good hypotheses and help us in making the preliminary investigation in any subject matter, and ultimately with their help we are able to discover the right hypotheses, and prove it logically. Thus the function of these simulating inductions is widely different from the fallacious deductive reasoning which is not only useless but also harmful.

According to Mill Perfect Induction, Parity of Reasoning, and the Colligation of Facts are alone treated as processes simulating induction. He calls them Induction improperly so called. Let us consider them first. Thereafter we shall consider the processes of reasoning which approach the scientific induction but are not identical with it. We shall describe them as unscientific induction.

2. **Perfect Induction**. It is a form of reasoning by which we establish a universal real proposition after carefully observing all the possible particular cases covered by the universal proposition. As for instance, after examining all the fruits of a basket and finding every one of them sweet if we conclude that all the fruits of the basket are sweet then our reasoning will be a case of Perfect Induction. If we go to a village and examine all the villagers one by one without any exception, and find that every one of them is a Hindu, and then come to the conclusion that all the inhabitants of that village are Hindus, then our inference will be a case of Perfect Induction. Thus in a Perfect Induction we are required to observe a number of

instances. Here the observation is thorough, as we examine all the possible instances, while in scientific induction we examine not all the instances but only a few of them. Like scientific induction Perfect Induction establishes a universal proposition which can be relied on. It also establishes material truth. On account of these characteristics Perfect Induction resembles scientific induction, yet we cannot call it induction proper, as the conclusion is not more general than the premises, for the conclusion comprises only those cases which have been examined by us. In the above mentioned example the conclusion 'All the inhabitants of the village are Hindus', does not include an inhabitant whom we have not examined. Thus in Perfect Induction we proceed from all cases to all cases while in induction proper we proceed from some cases to all cases. So the conclusion arrived at by Perfect Induction does not cover any new case or new region—it is simply the summation or summary of the particular instances observed. Mill says that the conclusion of Perfect Induction merely reasserts the premises and is nothing but a short-hand registration of the facts known. In it we do not take any leap from the known to the unknown. Such a reasoning is called perfect because it establishes perfect certainty, whereas in induction proper absolute certainty cannot be arrived at.

Perfect Induction can hardly be treated as inference because it does not give us any new information and in it we do not proceed from the known

to the unknown, which are the peculiarities of all inference. Besides Perfect Induction is not grounded on the law of causation—it rests on the complete enumeration or examination of the instances covered by the conclusion. For these reasons Perfect Induction can neither be treated as induction proper nor as an inference. Yet it is not useless because if we know that all the books of an almirah to be books on Logic we can always go to it whenever we require a book on that subject. Similarly if we know that all the inhabitants of a village are Hindus we can infer what kind of customs, food, and cleanliness will be found there. Jevons says that "mere abbreviation of mental labour is one of the most important aids we can enjoy in the acquisition of knowledge. The powers of the human mind are so limited that multiplicity of detail is alone sufficient to prevent its progress in many directions". So he concludes that Perfect Induction even as a process of abbreviation is absolutely essential to any high degree of mental achievement (*The Principles of Science*—pp148-49).

But a true universal proposition cannot be established by perfect Induction because such a universal proposition practically comprises an infinite number of instances occurring in the past, present and future, and it is impossible for us to examine all these instances. We cannot examine the mortality of all the living human beings, not to speak of the future generations to be born. Hence it is not possible for us to establish 'All men are mortal' by Perfect Induction—it can establish only a qualified

universal proposition limited to a praticular place and time and implying only a few praticular instances.

Dr. P. K. Ray says that after examining all the known planets and finding them moving round the sun if we conclude that all the known planets move round the sun we have a case of perfect induction Such a reasoning according to him implies that in future all these planets will continue to move round the sun. Hence Perfect Induction involves generalisation and rests on the uniformity of nature But the moment the future and the past are brought in, the Perfect Induction ceases to establish perfect certainty and becomes identical with Imperfect Induction which establishes probable conclusions. When the future cases are brought in, Dr. Ray's example becomes equivalent to : At present the known planets are found to move round the sun and so they do so always, which is purely a case of imperfect induction. Hence we conclude that Perfect Induction refers only to the time when the observation of the instances is made and not to the past and the future

3. **Imperfect Induction.** As opposed to Perfect Induction we have Imperfect Induction. In it we establish a real universal proposition after an examination of only a few instances, but not all. It is grounded on uncontradicted experience and not on the law of causation. So it is different from induction proper. Most of our popular generalisations are imperfect inductions. When the number of instances

on which Imperfect Induction is grounded is very few it is said to be a case of hasty generalisation. Finding in a town a dozen people to be dishonest if we conclude that all the inhabitants of the town are dishonest we commit the fallacy of hasty generalisation. But when a vast number of instances are observed and the possibility of getting a contradictory instance is removed, and a generalisation is made on the strength of these instances then our inference becomes a case of Imperfect Induction. As for instance, after examining a number of metals we find that all of them conduct electricity, and if we fail to come across a case of metal which does not conduct electricity then we can make the generalisation that all metals conduct electricity. Our inference in this case becomes a case of Imperfect Induction. Similarly if we examine the crows of different places and find that without any exception all the crows observed by us are black then we can make the generalisation that all crows are black, on the ground of uncontradicted experience.

In Imperfect Induction we find the following features :—(a) It is based on observation ; (b) it establishes material truths, (c) and universal real propositions ; and (d) its conclusions are more general than the premises. These are also the characteristics of scientific induction. On account of these points of similarity Imperfect Induction appears to be induction proper. Yet it is different from scientific induction as it is not grounded on the law of causation. So imperfect induction may be

treated as a process simulating induction. But we can improve an imperfect induction by further investigation, and by employing the experimental methods we can base it on the law of causation. When thus proved imperfect induction becomes methodical and identical with scientific induction. When it is not so proved, i. e., when it is grounded simply on the uncontradicted experience or enumeration of the instances it becomes identical with **Simple Enumerative Induction**, and is said to be Immethodical Imperfect Induction. Thus there are two kinds of Imperfect Induction, viz.. **Methodical Imperfect Induction** which is identical with scientific induction and **Immethodical Imperfect Induction,** which is identical with Simple Enumerative Induction. The imperfect character of generalisation is achieved when a universal real proposition is arrived at after an examination of a few of the instances covered by the universal proposition and the conclusion is more or less probable. Hence the scientific induction has this imperfect nature. The imperfect induction is called imperfect because it establishes imperfect certainty as opposed to the perfect certainty established by Perfect Induction. Mill did not treat it as a case of simulating induction. We may call it an unscientific induction.

Now Perfect Induction can also be improved into a scientific induction by basing it on the law of causation or proving the relation involved by the experimental methods. But in this case the

conclusion will cover an infinite number of instances and will be more general than the premises, and so the perfect induction will cease to be a perfect induction. Thus we cannot transform Perfect Induction into scientific induction without destroying its nature. For this reason it may be said that Perfect Induction cannot be transformed into scientific induction.

4. **Induction by the Parity of Reasoning.** It is a kind of reasoning in which we establish a relation with reference to a praticular instance, not by observation but by reasoning, and on account of the applicability of the parity of reasoning or the same reasoning without any modification to all similar instances, the relation proved in the praticular instance is generalised and thereby a universal proposition is arrived at. As for instance we draw a triangle and prove with reference to it that its three angles are equal to two right angles, and on account of the applicability of the parity or the same reasoning to all possible triangles we make a generalisation and conclude that in all triangles the three angles are together equal to two right angles. Thus we seem to proceed from a single instance to all such instances of the same class and the conclusion is more general than the premise. Hence Induction by Parity of Reasoning appears to involve generalisation, i. e., appears to be inductive in form. But it is not really induction, because in inductive investigation the truth in the particular instances

is arrived at by observation or experiment and never by reasoning, while in induction by parity of reasoning the truth in the particular instance is arrived at not by observation, but by reasoning. The inductive conclusion requires to be verified, i. e., compared with facts, while we require no verification in induction by parity of reasoning. Induction proper is grounded on the law of causation while induction by parity of resoning is grounded on the applicability of the same reasoning to all possible cases. The former establishes rational certainty while the latter establishes absolute certainty. Besides in parity of reasoning we consider abstract things existing only in our imagination, while in induction proper we avoid all imaginary things and consider only those facts and phenomena which actully occur in nature. The triangle that is drawn cannot be a triangle because the bounding lines have breadth and the surface is not smooth. Thus induction by parity of reasoning as a form of generalisation involves the transcendental fallacy of induction. But as a matter of fact the induction by parity of reasoning does not involve any generalisation whatsoever. No mathematician argues that since the relation is true in one case it must be true in all other cases. Such a generalisation is entirely unnecessary in mathematics.

The induction by parity of reasoning is entirely deductive in character, because the conclusion follows deductively from the axioms, definitions, already established theorems, and the very nature

of the particular instance under consideration. It does not follow from the figure drawn either actually or mentally. The figure is drawn simply to fix our attention and help us in carrying out the deductive process of reasoning. Even a badly drawn figure serves our purpose. The very fact that a right conclusion can be drawn when the figure is badly drawn shows that the reasoning and the conclusion are independent of the figure drawn. Thus we conclude that induction by parity of reasoning is no induction—it is wholly deductive in character. Such a reasoning is widely used in Geometry, and so it may be called Geometrical reasoning, but it must not be confused with the Geometrical Method which is a complex deductive method. Induction by parity of reasoning is also called simply Parity of Reasoning by many.

5. **Mathematical Induction.** When by observing a number of similar instances in mathematics we establish a universal proposition on the strength of uncontradicted experience we have a case of mathematical induction, e.g.,

$$1+3=4=2^2$$
$$1+3+5=9=3^2$$
$$1+3+5+7=16=4^2$$
$$1+3+5+7+9=25=5^2$$
$$1+3+5+\ldots\text{to n terms}=n^2$$

i.e., the sum of the consecutive odd numbers beginning with unity is equal to the square of the number of terms in the series. Here we have examined four cases of odd numbers beginning with unity, and we find

that in each of these cases the sum is equal to the square of the number of terms in the series." On account of this similarity in the result the conclusion is generalised and we maintain that it is so in every case. Thus in mathematical induction we proceed from some cases to all cases, i. e., from the known to the unknown. and in the particular instances the truth is arrived at by observation. Hence mathematical induction is more inductive in character than the induction by parity of reasoning. Yet it cannot be called induction porper, for it is not based on the law of causation or on the experimental methods. It is based on uncontradicted experience and is similar to Simple Enumerative Induction which proceeds from some cases to all cases on the strength of uncontradicted experience. But there is a great deal of difference between it and simple enumerative induction because mathematical induction establishes absolute certainty, while simple enumerative induction establishes only probable conclusions. Besides the mathematical quantities are not events in time, and so to apply inductive characteristics to them is to commit the transcendental fallacy of induction.

Mathematical induction has been included by Mill within induction by parity of reasoning, but on account of the great difference between them it is not proper to identify the one with the other. It should be noticed that mathematicians never rely on such reasoning or on uncontradicted experience. They always apply deductive calculation in order

to be sure of the conclusion arrived at by mathematical induction. In the above mentioned example the mathematician will take the next series and verify the conclusion by direct calculation, e. g.,

$$1+3+5+\ldots+(2n-1)+(2n+1)=n^2+2n+1=(n+1)^2$$

There are $n+1$ terms and the sum is $(n+1)^2$. Hence it is inferred that if the result is true of n terms it must be true of $n+1$ terms. By direct calculation the result has been found to be true up to five terms. Hence it must be true of six terms. When it is true of six terms it must be true of seven terms and so on. For this reason the result must be true in all cases.

Thus we find a great deal of deductive calculation in the cases where mathematicians use mathematical induction, and on account of this deductive element such a reasoning gives us absolute certainty. Besides mathematical induction considers cases of co-existence while induction proper considers cases of succession. Hence mathematical induction cannot be treated as induction though it appears to be so. By mathematical induction a universal truth can be discovered but it cannot be proved by it.

6. **The Colligation of Facts.** This is a process by which we mentally colligate, i. e., bind together mentally into one comprehensive whole all the particular instances experienced by us in connection with the subject matter under investigation, and then express this united whole by some

appropriate conception. Thus an astronomer views only the particular positions of a planet one after another. These positions cannot be observed simultaneously. But the astronomer mentally colligates all these positions and expresses this colligation by the conception of an ellipse Similarly when a navigator views land in an ocean he cannot say whether it is an island or a continent. But by coasting round it he observes all the points of the bounding line one after another and then he mentally binds together, i. e., colligates all these particular experineces into one whole, and then expresses this united whole of praticulars by the conception of an island, i. e., he concludes that the tract of land is an island. Thus in colligation we proceed from the particulars to the general because the concept is an idea of a class of facts and is therefore general. So Dr. Whewell regards colligation of facts as induction. According to him the most essential factor of induction is the discovery of the concept which will express a class of facts and will help us in binding together all these facts into one whole.

But Mill maintains that colligation cannot be induction for it does not proceed from the known to the unknown and so it does not take any risk in inferring anything as to the unknown facts, which is the essence of induction. Colligation according to him is simply a summation of the facts observed and is therefore the reassertion of the particulars observed by us. But it helps us in describing the particulars observed and in forming hypothesis, and as such it is a step to induction.

In a true induction we proceed from a number of particular instances to a universal proposition which binds together into one whole all these particular instances together with a large number of similar instances, e.g., Ram is mortal, Jadu is mortal, Mohan is mortal, etc., therefore all men are mortal. Here the conclusion binds together into one whole the mortality of Ram, Jadu, etc., as well as the mortality of a large number of unobserved persons. Thus every induction involves colligation of facts. It is on account of this Whewell maintains that colligation is induction. Mill objects to this and holds that it is not so. Induction according to him implies colligation but every case of colligation does not imply inductive reasoning, e.g., in conception we bind together into one whole a number of common essential attributes. Yet conception is not induction, because in it we have no causal relation and no universal proposition as our conclusion. In perfect induction, definition, description we have colligation but no induction. Mill admits that colligation is subsidiary to induction and is a necessary preliminary to induction. But induction does not simply discover the appopriate concept or hypothesis (which is colligation), but proves it. Therefore induction is more than colligation. Besides colligation is generally concerned with cases of co-existence while Induution is concerned with cases of succession. But colligation cannot be treated as a deductive process as in it we proceed from the particulars observed and want

to establish material truth. Deduction comes in when the concept is examined, i.e., when conclusions are deduced from it and compared with facts.

In connection with the controversy about the colligation of facts there is a controversy regarding the nature of the process by which Kepler discovered the orbit of the Mars to be an ellipse. Kepler observed the different positions of the Mars and framed different hypotheses which will explain all these positions. Trying curve after curve he at last made the hypothesis that the orbit is an ellipse. He made further observations of the position of the Mars and found that they are in harmony with his hypothesis. So he concluded that his hypothesis is true and the orbit of the Mars is an ellipse. Here we porceed from some positions of the planet to all its positions (Some positions are on an ellipse, therefore, all positions are on an ellipse). Hence it involves generalisation, formation of hypothesis, exclusion of rival hypotheses, and verification. Hence there is every justification for us to treat it as an induction. Had it been possible for us to see the ellipse in the sky and the positions of the Mars existing on this ellipse then it would have been proper for us to maintain that it is a case of pure colligation involving no inference. Much confusion has arisen as to the nature of colligation by overlooking the point that the essential factor of colligation is the discovery of the concept which will mentally bind together the particulars

in questions. Such a discovery involves inference and cannot be had in deduction.

7. **Unscientific Induction.** Under this heading we shall consider the Enumerative Inductions known as Simple Enumerative Induction, Complete and Incomplete Induction. These processes involve real generalisation but they fall short of scientific induction as they are not grounded on the law of causation. These should not be treated as useless as they suggest hypotheses and pave the way for scientific induction. They have immense practical value and are commonly employed by us in our daily life.

8. **Enumerative Induction.** It is a kind of generalisation in which the conclusion is grounded not on the law of causation, and not on the **nature** of the instances observed but simply on their **number.** 'All crows are black,' 'All swans are white' 'All scarlet flowers are odourless' are generalisations grounded simply on the number of instances and not on their nature.

There are two kinds of Enumerative Induction, viz., **Complete Enumerative Induction** and **Simple Enumerative Induction.**

Complete Enumerative Induction consists in establishing a universal real proposition on an examination of all the possible instances covered by the universal proposition. The validity of the conclusion rests simply on the **number** of instances observed and not on their **nature.** Such a reasoning

gives us perfect certainty and is identical with Perfect Induction.

9. **Simple Enumerative Induction**. It consists, on the other hand, in establishing, on the strength of uncontradicted experience, a universal real proposition on an examination of some of the instances covered by the universal proposition. Here also the generalisation is grounded on the **number** of instances observed by us and not on their **nature**. Such a reasoning gives us probable conclusion, and is often called only Simple Enumeration. Thus by observing A_1 is x, A_2 is x, A_3 is x, A_4 is x, etc., we conclude that all A's are x, simply on the strength of uncontradicted experience without applying the experimental methods and without establishing any causal connection between A and x. 'All swans are white', 'All crows are black', 'All scarlet flowers are devoid or fragrance', 'All horned animals are herbivorous', 'All tom-cats with blue eyes are deaf', etc., are all arrived at by simple enumerative induction. In all such cases we observe a few instances only and find them similar in some respects, and from that similarity we draw an inference without caring to observe whether there is any causal relation or whether the similarity is essential or fundamental in nature.

The value of an inference by simple enumeration is very small from the logical stand point, as it gives us only probable conclusions. But it suggests good hypotheses and as such its scientific value is very great. On it almost all the popular generalisa-

tions and beliefs are based to a considerable extent. But according to Bacon such a generalisation is childish, useless and often mischievous. To accept Bacon's view is to reject all empirical generalisation which is the name given to the conclusions arrived at by simple enumerative induction.

The conclusion arrived at by simple enumeration holds good with regard to analogous or *adjacent cases* existing in the circumstances and places similar to those from which the instances have been gathered. It is a fallacy to extend a conclusion arrived at by simple enumeration to cases existing in widely different circumstances, e. g., if by simple enumeration we conclude that an average Indian earns a rupee a day, it will be a fallacy to extend it to the Americans and maintain that an average American also earns a rupee a day. Similarly if by observing the crows of India we come to the conclusion that all crows are black, it will be risky to extend this conclusion to the crows of the Arctic region and Australia where the circumstances are quite different. In accepting the conclusion of simple enumeration as true we should always examine the possibility of getting a contray instance because a single contrary instance is sufficient to destroy the conclusion arrived at by simple enumeration. When we overlook this possibility of getting a contrary instance we are said to make a hasty generalisation, e. g., foreign travellers are often found to condemn a nation simply because they happen to come across a few bad members of that nation Miss Mayo's

generalistations about India are all hasty, because she drew conclusions in each case about a nation of millions after an examination of ten or at most twenty members of that nation.

Though simple enumerative induction is grounded on the number of instances observed by us yet the strength of such a reasoning depends on the nature of the points of similarity about which generalisation is made. But its real strength depends on the width of the observation made and the possibility of getting a contrary instance. The more extensive the observation, the more is the possibility of our conclusion being true. If we examine the peasant proprietors of India, China, Australia, Russia, America and Africa and then conclude that all peasont proprietors are economical then our conclusion will be likely to be true.

Induction by simple enumeration appears to be a form of inference based on the Method of Agreement but really there is a great deal of difference between them. The Method of Agreement requires the isolation of the essential elements from the non-essential or accidental ones, while no such elimination is necessary in induction by simple enumeration. Besides cases of sequence are only considered by the Method of Agreement while induction by simple enumeration generally considers cases of co-existence. Another distinction betweeu them is that in the Method of Agreement we try to exclude or disprove all rival hypotheses while no such thing is done in induction by simple enumeration.

10. Complete and Incomplete Induction. By Complete Induction we mean a process of reasoning in which we establish a universal real proposition after an examination of a few particular instances. It is said to be complete because the proposition established by it governs a complete class of facts superseding for ever the labour of further investigation regarding the problem with respect to the class of facts examined. In such an induction we proceed from some cases to all cases and the conclusion is more general than the premises. Hence it is similar to imperfect induction, but the reasons underlying these two names are different. The same reasoning is called imperfect because it establishes inperfect certainty, and is called complete as it governs a complete class of facts without any exception. Any and every case of complete induction is not induction proper. In some cases it is based on the law of causation or the experimental methods, while in other cases it is grounded simply on uncontardicted experience. In the former case it is said to be methodical and is identical with scientific induction, while in the latter case it is said to be immethodical and is identical with simple enumerative induction or popular, hasty generalisation. Thus Complete induction is of two kinds, viz., methodical and immethodical. The immethodical complete induction is widely different from scientific induction. Some writers have used Complete induction in the sense of generalisations which completely follow the rules of induction. In this

sense Complete induction becomes identical with scientific induction. It should be carefully noticed that Complete induction is different from Complete Enumerative induction which is identical with Perfect Induction.

By **Incomplete induction** on the other hand we mean approximate generalisation based on the observation of a number of particulars. Such a reasoning is grounded on uncontradicted experience, and the conclusion established by it holds good in most of the cases, but not in all cases. So sufficient room is left open for further investigation. "Most honest people are successful". "Most plague cases are fatal" are arrived at by incomplete induction. Thus Complete induction establishes conclusions governing an entire class of facts without any exception, e g., 'All men are mortal', while Incomplete induction establishes conclusions governing most of the cases under investigation. In incomplete induction the conclusion is more general than the premises. Some writers have used incomplete induction in the sense of generalisations which incompletely follow the rules of scientific induction. In this sense it becomes identical with simple enumeration. Incomplete induction has also been used in the sense of arguments based on observation and establishing real material propositions without developing and proving the universal propositions on which the conclusion is grounded. In such reasonings we simply assume the universal implicitly. Such is the case in Analogy where we proceed from

a particular to another particular, apparently without the help of any universal proposition but really with the help of some universal proposition. In the analogical argument "The mars is inhabited as it resembles the earth with respect to land, water, and atmosphere' we seem to pass from the earth to the mars on the strength of resemblance, but actually we assume the universal proposition that all planets having land, water, and atmosphere are inhabited which warrants our conclusion about the mars. We shall consider this in Analogy later on.

11. Exercises.

1. What do you mean by Simulating Induction? Why is it so called? What are its various forms?

2. Distinguish betwen Simulating Induction and Induction proper. Do you consider Simulating Induction completely useless?

3. Explain and illustrate Perfect Induction. Why is is called perfect? Distinguish it from Imperfect Induction.

4. Describe the nature of Perfect Induction. Is it an inferential process? Is it useless? Does it involve any generalisation? Can such a reasoning be developed into Induction proper?

5. Explain the nature of Imperfect Induction. Why is it so called? On what is it grounded? Explain and illustrate its different forms.

6. What is the evidentiary value of Imperfect Induction ? Distinguish it from Induction proper.

7. Explain and illustrate Induction by parity of Reasoning. On what is it grounded ? Is it deductive or inductive ? Give reasons for your answer.

8. What is Mathematical Induction ? Is it identical with Induction by Parity of Reasoning ? What kind of truth is established by Mathematical Induction and why ?

9. Explain and illustrate Colligation of Facts. Does it involve any generalisation ? Examine the statement : Induction is Colligation of Facts, and Collingation of Facts is Induction.

10 Explain the various forms of Unscientific Induction. Are they identical with Simulating Induction ? What are the grounds of Unscientific Induction ? What kind of truth is established by such an induction ?

11. Explain and illustrate the various forms of Enumerative Induction. On what are they grounded ? What kind of truth is established by them ?

12. Distinguish between Simple Enumerative Induction and Induction proper.

13. Explain and illustrate Complete and Incomplete Induction. Why are they so called ? What are the forms of Complete Induction ?

14. Explain and exemplify the process which Bacon called Inference from Simple Enumeration. Explain in what its inferiority consists, and how it differs form scientific Induction.

15. You draw an isosceles triangle on board, and prove that its two basal angles are equal, and then draw the conclusion that all isosceles triangles have

their basal angles equal; explain the logical character of this conclusion.

16. 'All cases of reasoning in which the premise or premises are particular facts are cases of Induction'; accepting this as a definition of Induction, show from it what chief kinds or forms of Induction will be; and indicate the logical value of each giving example.

17. What are the different kinds or processes that simulate Induction? Exhibit and illustrate each of them and explain in each case why the process is not real Induction.

18. Distinguish between Perfect and Imperfect Induction, and discuss the question whether Perfect Induction is demonstrative and syllogistic, while Imperfect Induction is neither.

19. Explain the meaning and scope of Induction, distinguishing it from processes which are improperly called Inductions. Show by a concrete example that inductive inference admits of being thrown into the deductive form.

20. Define Induction. Perfect Induction and Induction by parity of reasoning are improperly called induction. Why? What is Induction by Simple Enumeration?

21. What are the marks of Inductive inference? How does Induction differ from Colligation of Facts?

22. Distinguish beteen Scientific and Popular Induction. Which of these constitutes Induction proper, and why? Explain Hasty generalisation.

CHAPTER III

The Grounds of Induction.

1. **The Nature of the Grounds.** Induction, we have seen, is a process of reasoning by which universal real propositions are established after an examination of a number of facts. These universal real propositions are the laws of nature, and each of these laws is a uniformity of nature. Now if there be no uniformity in nature it will be impossible for us to establish any universal real proposition. Hence Induction assumes or postulates that there is uniformity in nature. It is for this reason that the Uniformity of Nature is treated as one of the grounds of induction.

Again the process of generalisation by which the inductive conclusion is arrived at requires a relation to be generalised. This relation must be of such a nature that we can infer one event from another. If the facts and phenomena occurring in nature were isolated from one another it would have been impossible for us to infer the one from the other, and so induction or the establishment of universal real propositions would have been impossible. Hence Induction supposes the Law of Causation which introduces relation amongst the facts and phenomena occurring in nature, and maintains that every event has a cause. It is in

this way that the Law of Causation has come to be treated as one of the grounds of induction.

The aim of Induction, we have seen, is the establishment of material truth. Now we cannot realise this end unless the premises from which the conclusion is arrived at are all materially true. We get these premises of Induction therefore by observation and experiment. Had it not been possible for us to get accurate information of the facts and phenomena occurring in nature with the help of our sense organs, i.e., by means of observation and experiment, the acquisition of materially true premises would have been impossible, and so the establishment of universal real propositions or induction would have been impossible. Hence induction supposes that our sense organs do not deceive us, but with their help we can get correct information of the facts and phenomena occurring in nature. Thus observation and experiment also are treated as the grounds of Induction. The matter or premises of Induction are supplied by observation and experiment, and so they are called the **material grounds of Induction**, while the very form of Induction, i.e., the passage from some cases to all cases, becomes impossible without the Law of Causation and the Uniformity of Nature. Hence they are called the **formal grounds of Induction.**

The grounds of Induction, therefore, are of two kinds, viz., (1) formal and (2) material.

The formal grounds of Induction are

(i) the Law of the Uniformity of Nature,

and (ii) the Law of Causation.

The Law of the Uniformity of Nature is sometimes called the Principle of Similarity or the Law of Identity, and the Law of Causation is sometimes called the Principle of the Ground and Consequent.

The material grounds of induction are (a) **observation** and (b) **experiment.**

Without the formal and the material grounds of Induction no inductive reasoning is possible. All Inductions suppose the validity of the Uniformity of Nature and the Law of Causation, and are in fact based on them. The Law of Causation supplies us with the binding link between the objects and phenomena, and thereby makes it possible for us to infer the one from the other. The Uniformity of Nature on the other hand permits us to proceed from some cases to all cases, i.e., from the known to the unknown. Every induction must be based upon some facts or phenomena given to us by observation and experiment and not created out of our imagination. We call them grounds because they constitute the basis or foundation on which Induction stands. These are also called the **conditions of Induction** as they make the inductive reasoning possible. They are sometimes called the **postulates of Induction** as they are supposed in logic without any proof in order to make induction possible.

The problem of the Uniformity of Nature really

belongs to Philosophy. In Logic we simply assume or postulate its truth. The Law of Causation is also assumed or postulated in Logic. The idea of causation and its reality are the subject matter of Philosophy. Observation and Experiment are Psychological problems. Whether they give us exact information of the objective world is a problem of Philosophy. They are also postulatod in Logic. The validity of the Uniformity of Nature, the Law of Causation, Observation and Experiment is not proved in Logic.

2. **The Uniformity of Nature.** By the uniformity of nature we mean that under identical circumstances nature behaves in the same way, e.g., when a man takes an ounce of opium death occurs. The Uniformity of Nature tells us that death will occur always in case a man of similar constitution takes that quantity of opium. We know that fire burns now and the uniformity of nature tells us that fire will burn even after thousands of years. Symbolically it can be illustrated thus: Suppose we find that in the circumstances **ABCD**, **x** occurs, then by the uniformity of nature we know that whenever and wherever **ABCD** will occur, **x** will take place. But by the Uniformity of Nature we do not mean that nature exists in one unchangeable state, and only one thing or phenomenon occurs everywhere in nature, for it is well known to us that nature is vastly diverse. Behind these diverse facts and phenomena there are uniform laws and principles operating in nature,

and binding all the diverse facts into a systematic whole. The uniformity of nature, therefore, implies that the world is a system.

If we do not take for granted this law of the Uniformity of Nature it would become quite impossible for us to reason in any way, and as a matter of consequence every thing will be probable. Water we know quenches our thirst and is not poisonous. If nature be not uniform, water may change its quality a moment after, and become a highly burning and poisonous liquid; man is mortal to-day, but he may cease to be mortal from to-morrow: man can think to-day, but he may be deprived of the power of thinking to-morrow. Thus we see that the data on which our reasoning is based will change every moment if nature be not uniform. So the very possibility of reasoning supposes that nature behaves in the same way under identical circumstances. Besides we have seen that in induction we pass from the known to the unknown. Now if the unknown and the future be quite different from the known and the present it would be quite unreasonable to extend the truth that holds good with regard to the known and the present to the unknown and the future. The Uniformity of Nature guarantees the essential similarity between the known and the unknown, the present and the future, and allows us to draw an inductive conclusion. Besides the problem of Induction is to establish universal real propositions in harmony with facts. These universal real pro-

positions suppose uniformity. There cannot be any real universal proposition if there be no uniformity in nature. So induction becomes impossible if the facts on which it is based fail to behave uniformly, i.e., if nature be not uniform. As the Uniformity of Nature is supposed in all inductive generalisation, and as without it no generalisation is possible the Uniformity of Nature is called the guarantee or the **ultimate major premise of all Induction.**

In deductive reasoning we always require a universal major premise when the argument is in the first figure. In order to prove this universal proposition we require another universal premise. This again is to be proved by another universal major premise. In this way we proceed from one universal to another universal major premise. Had it been necessary for us to continue *ad infinitum* it would have been impossible for us to prove any proposition. But as proof is possible, this process halts at a place, and this halting place is the Uniformity of Nature. For this reason also the Uniformity of Nature is treated as the ultimate major premise of all reasoning.

3. **The Unity of Nature.** Why is nature uniform ? Instead of calling the fundamental principle by the name of the Uniformity of Nature, **Welton** has called it the Unity of Nature, or the Law of Identity. If nature be not under the control of one principle, if it be governed by diverse powers, eternal conflict and diversity as opposed to regularity or uniformity would have reigned

supreme in nature, leaving no room for any form of inference either deductive or inductive. So Welton maintains that in order to make induction possible we must suppose the unity of nature or that nature is governed by only one principle and not by many. Hence the doctrine of pluralism cannot be reconciled with the problem or Induction.

According to most of the logicians of the present day, the knowledge of reality or material truth supposes that the world is a system containing within it many correlated parts. In other words our knowledge of reality as well as of sensuous exprience supposes identity of the universe in which we live and the identity of reality about which we form our knowledge. But as time involves change, our idea of things must not only suppose identity, unity, and persistence, but also change, diversity or multiformity. This change is the change of substance that persists. We know from Philosophy that formal identity apart from any change is unthinkable. Real identity is only known in the midst of diversity. In other words reality supposes phenomena or change, identity supposes difference, unity supposes diversity. and uniformity supposes multiformity and the one apart from the other is unthinkable. But diversity can hardly be the basis of any inference, i.e., no inference can be had without identity. So Welton maintains that the unity or identity of nature is the fundamental postulate of knowledge and this unity of nature implies the uniformity of nature.

The Uniformity of Nature cannot be defined as it is supposed in all definitions. It is therefore liable to be misunderstood. This principle is implied in all the common maxims and in the conduct of men and animal. It is also the foundation of all the sciences which are entirely occupied in seeking the laws or uniformities of nature. To make the principle of the Uniformity of Nature more definite it is better to mean by it that the same cause produces the same effect. In this sense the law of the Uniformity of Nature becomes an aspect of the Law of Causation, which means that every event has a cause.

4. **The Uniformities of Nature.** There are various aspects of the Unifromity of Nature. These are also called the kinds of uniformities. The principal kinds of uniformities are the uniformities of succession, the uniformities of co-existence, and the uniformities of equality or inequality. The classification of these uniformities is identical with the classification of laws. Besides the axioms and the fundamental laws of Logic and Mathematics together with their corollaries we have the principle that all times and spaces are commensurable, i. e., time flows in the same way and space is extended in the same manner everywhere. "Time does not trot with one man and gallop with another as it seems to do, but it flows uniformly. Similarly space does not swell in places, otherwise life, experience and mathematics would have been impossible" (C. Read). We have also the law of the persistence of matter

and energy otherwise known as the law of the Conservation of Energy. Of the laws of succession some are due to causation and some are simply empirical, while the laws of coexistence may be geometrical or natural. The laws of natural co-existence are so very great and diverse in nature that it is difficult to classify them.

Now the question is whether it is correct to speak of the uniformity of nature as the formal ground of Induction. Induction tries to establish these various uniformities of nature and to suppose them as the ground of induction itself is to commit the fallacy of *petitio principii*. Besides isolated cases of uniformity will make the world disorganised, and so chaotic, making our knowledge of this world almost impossible. For inference and knowledge we require an organised or systematic world or cosmos which is possible only when there is a unity in nature. Moreover the idea of the uniformities of nature suggests and implies that these are the various aspects of the Uniformity of Nature. Hence the Uniformity of Nature is deeper and more fundamental than the uniformities of nature, and so it is better to treat the Uniformity of Nature instead of the uniformities of nature as one of the formal grounds of induction. To remove all this confusion Welton has proposed to treat the Unity of Nature as the formal gronnd of Induction instead of the Uniformity or Uniformities of Nature, and he means by it that the universe is not an unchanging identity but that it is a system which remains

identical with itself amidst the unceasing changes of relations between its parts.

Having the various aspects of the Uniformity of Nature in mind Mill maintains that it would be better to speak of the uniformities of nature instead of the uniformity of nature as the formal ground of induction. Welton rightly holds that our aim is surely to establish these uniformities or laws of nature in science, but if we assume these uniformities as the fundamental principle of all reasoning and conception, then the unity of the universe and thought will be lost, and the universe will be reduced to a chaos. For our reasoning we do not require separate isolated uniformities or laws but united, interrelated laws, i. e., the unity of nature or an one in the midst of many. It should be borne in mind that variety also exists in nature and is equally necessary for thought and being.

5 **Uniformity and Similarity.** Are they identical ? Uniformity does not mean mere resemblance or similarity but identity of conditions. Arguments based on mere resemblance or similarity (as in Analogy) are not trustworthy, as mere resemblance cannot give us any firm basis of inference. From this standpoint we notice that Mill was not right when he meant by the Uniformity of Nature that the unknown will be similar to the known and the future will resemble the past. Welton rightly maintains that we have no right to assume these truths, nor is it necessary for us to assume them for the sake of knowledge The future may be un-

like the past without doing any harm to Induction. If the present day conditions be repeated then and then only the present day phenomena will occur again. But the Uniformity of Nature does not guarantee the repetition of the present day conditions. Welton also holds that from mere likeness of isolated phenomena we can draw no safe conclusion at any time. It is from the identity of conditions that a reliable conclusion can be arrived at. In order to avoid this ambiguity Welton has spoken of Unity rather than Uniformity as the postulate of Induction.

6. **The Origin of our belief in the Uniformity of Nature.** How do we get the idea of the Uniformity of Nature? There are three views as to the origin of our belief in the Uniformity of Nature.

(i) The *apriori* view which maintains that by intuition we ascertain the truth of the Uniformity of Nature. It precedes all experience and inference, and as such it is not derived from them. It is also presupposed by all experience. In fact it makes knowledge and experience possible. This view is generally maintained by the rationalistic or idealistic school to which most of the logicians of the present day belong. But it should be distinguished from the view which maintains that our belief in the uniformity of nature is innate, i. e., it is implanted in our mind in a ready made fashion at the time of our birth and we need not learn it at all. Had this been the case a child and an illiterate man would have clearly understood this principle.

like the past without doing any harm to Induction. If the present day conditions be repeated then and then only the present day phenomena will occur again. But the Uniformity of Nature does not guarantee the repetition of the present day conditions. Welton also holds that from mere likeness of isolated phenomena we can draw no safe conclusion at any time. It is from the identity of conditions that a reliable conclusion can be arrived at. In order to avoid this ambiguity Welton has spoken of Unity rather than Uniformity as the postulate of Induction.

What is the ground of our belief in the Uniformity of Nature?

6. **The Origin of our belief in the Uniformity of Nature.** How do we get the idea of the Uniformity of Nature? There are three views as to the origin of our belief in the Uniformity of Nature.

Is it derived from intuition?

(i) The *apriori* view which maintains that by intuition we ascertain the truth of the Uniformity of Nature. It precedes all experience and inference, and as such it is not derived from them. It is also presupposed by all experience. In fact it makes knowledge and experience possible. This view is generally maintained by the rationalistic or idealistic school to which most of the logicians of the present day belong. But it should be distinguished from the view which maintains that our belief in the uniformity of nature is innate, i. e., it is implanted in our mind in a ready made fashion at the time of our birth and we need not learn it at all. Had this been the case a child and an illiterate man would have clearly understood this principle.

(b) Mill himself states that the course of nature is infinitely diverse.

(c) Mill holds that we get this principle of uniformity from facts by abstraction. But this cannot be. For if by facts we mean experience *as felt* then in them we shall find only diversity and in order to understand it we must impose on it the conception of unity. If by facts we mean experience *as thought* then to make abstraction possible the idea of unity or uniformity must have been present there already, and so the idea must have been *apriori.*

(d) Accroding to Mill this principle is derived from an agument known as induction by universal agreement or induction by simple enumeration which Mill himself has condemned as a means of attaining knowledge. This is sometimes called the Paradox of Induction because accroding to this view the ground of all Induction is viewed as the conclusion of a process of Induction known as Simple Enumeration Hence if we consider Mill to be right in his view of the Uniformity of Nature the whole process of Induction will be faulty, probable, and nugatory. (Welton)

(e) Had this idea been derived from observation it would have been known to every body. The fact that it is confined to the philosophers shows that it is not derived from experience This criticism was urged by Mill against the view which maintains that the idea of the uniformity of nature is an innate idea.

Hence we conclude that the notion of the uniformity of nature is not derived from experience.

(iii) The Evolutionist theory which maintains that our remote forefathers derived this law of the uniformity of nature from experience, i.e., to them this belief was *aposteriori*. But by the process of evolution this knowledge became so ingrained in the human system that in inheriting our mind and body from our parents we now inherit this belief also. So this belief is in our mind from our birth, and we need not learn it at all. Thus to us this belief is *apriori*. In this way what was acquired by our remote ancestors becomes inherited by us. This view is maintained by Herbert Spencer, and his school. It tries to reconcile the *apriori* with the *aposteriori* view. But this can hardly be called an explanation as it assumes the very thing to be explained. It does not explain how experience can be possible without presupposing the truth of the Uniformity of Nature. And so we fail to understand how our remote ancestors derived it from experience. Thus we conclude that the idea of the uniformity of nature is an *apriori* idea, though experience is necessary to make it explicit.

6. **The Principle of Similarity.** It is popularly believed that things similar in some respects are also similar in other respects, e. g., if **A** and **B** happen to be similar with regard to the attributes **p, q, r,** then if we find that **A** possesses the attribute **x** we can infer that **B** will also be similar with regard to **x**. This popular belief lies at the bottom

of all analogical arguments. But it is not a reliable principle. If Ram and Shyam happen to come from the same village, belong to the same class, have the same age and the same weight and complexion it would be wrong to maintain that if one of them is reliable, the other is also reliable. This principle is a popular version of the Uniformity of Nature and the Law of Identity.

7. Exercises.

1. What are the Grounds of Induction ? Why are they called Grounds?

2. What are the Postulates of Induction ? Why are they called Postulates ?

3. What are the Conditions of Induction ? Why are they called Conditions ?

4. What are the Formal Grounds of Induction ? Why are they called Formal Grounds ?

5. What are the Material Grounds of Induction ? Why are they called Material Grounds ?

6. Explain the nature of the Grounds of Induction. Are they assumed or proved in Induction ?

7. Explain and illustrate the Law of the Uniformity of Nature. What part does it play in Induction ?

8. Why is nature uniform ? Explain what is meant by the Unity of Nature.

9. Take a concrete case of inductive reasoning and show how it depends on the various Grounds of Induction.

10. Explain the statement: The Uniformity of Nature is the ultimate major premise of all inductions and deductions.

11. Give a critical estimate of the view that the Uniformities of Nature constitute the formal ground of Induction.

12. Explain and illustrate the various forms of the Uniformity of Nature. With which of them is Induction concerned?

13. What is the ground of our belief in the Uniformity of Nature?

14. How do we get the idea of the Uniformity of Nature?

15. Give a critical estimate of the view that we get the idea of the Uniformity of Nature by repeated sense experience.

16. Explain the Principle of Similarity. Is it a reliable principle? What arguments are based on it?

17. (i) Explain and illustrate fully the principle of the Uniformity of nature. (ii) What are the fundamental kinds, classes or branches of Uniformity found in Nature? (iii) What do you consider to be the ground or evidence underlying the belief in Uniformity? (iv) What is meant by saying that Uniformity is the ground of Induction? (v) Do you consider cyclones and earth-quakes to be consistent with Uniformity?

18. The ground of Induction is itself an Induction. Fully discuss this. How can a conclusion which asserts more than the premises be valid? Fully discuss this question.

19 Explain and analyse the conception of the Uniformity of Nature, and show it forms the foundation of inductive reasoning.

20. How is Uniformity of Nature established? Is it, strictly speaking, an Induction? If not, explain precisely its relation to Induction.

21. Explain the grounds of Induction, Formal and Material; and examine the view that the ground of Induction is itself an Induction.

22. Explain what is meant by the Uniformity of Nature. Is the law of Uniformity of Nature an Induction from experience? Discuss the question.

23. What is the Paradox of Induction? How would you solve it? Give reasons.

CHAPTER IV

The Law of Causation.

1. **The Significance of the Law of Causation.** By the Law of Causation we mean that every thing or event occurring in nature has a cause. There is nothing in this world which is *causa sui*, (self-caused) not even the distant stars and the invisible objects lying at the bottom of the deep sea. God is the only reality which is *causa sui.* But He is neither a thing not an event of this world. So He falls outside the scope of the Law of Causation as defined in Logic. This law also implies that nothing of this world can happen by chance, and there cannot be any new beginning in this world of our experience.

The Law of Causation simply tells us that a phenomenon, say x, has a cause, say A. The question naturally arises whether (i) A will always produce x and (ii) x will be always produced by A. According to many philosophers both these things are implied by the Law of Causation because the idea of causation implies a necessary relation between the cause and its effect, and necessity implies uniformity and universality. Hence according to this view the Law of Causation implies three things viz.,

(i) Every event has a cause. (The Law of Caustion proper.)

(ii) The same cause always produces the same effect. (The Law of the Uniformity of Nature).

(iii) An event is always produced by the same cause. (The Law of Reciprocity).

There are some logicians who do not accept this view and maintain that the Law of Causation does not tell us that the same cause produces the same effect. This infromation is given to us by the Uniformity of Nature. The Law of Causation does not tell us also that the same event is produced by the same cause. This information is given to us by the Law of Reciprocity. So if we know that there is a causal relation between A and x, then on the strength of the Uniformity of Nature and the Law of Reciprocity we can generalise the relation and maintain that A will always produce x, and x will be always produced by A. Thus causal relations always give rise to universal real propositions the establishment of which is the fundamental problem of Induction. We find that the sun produces light and so we can generalise this relation and maintain that the sun always produces light , i. e., it produced light in the past and it will produce light in the future.

But here we come across one great difficulty. We find no doubt that whenever the sun is up we have light but we find in our experience that light is produced by different agents, viz., the sun, the moon gas, electricity, etc. Other events are found to be produced by different things (the plurality of causes), e. g., death is caused by disease, burning, drowning,

etc. Yet the Law of Reciprocity assures us that the same event is always produced by the same cause. In Logic and Science the Law of Causation is always viewed as modified by the Uniformity of Nature and the Law of Reciprocity, and the cause is defined as the invariable, unconditional, and immediate antecedent of an event and is quantitatively equal to it.

According to this definition the causal relation becomes a case of succession. But many philosophers maintain that no case of succession can give us any adequate idea of causation, for causation implies production and a necessary connection. This necessity existing between the cause and the effect can never be understood in a simple case of succession. Hence the above noted definition of the cause is not a definition. Had it been a definition the word 'unconditional' would have been objectionable as condition is a synonym of cause and one cannot be understood apart from the other. The idea of causation is so very fundamental that it cannot be defined as any and every definition presupposes it. It is regarded by many as one of the very forms of thinking and so every case of thinking implies it and rests on it. For this reason the scientific definition of the cause as a definition is defective. It simply gives us the marks or signs by means of which the causal relation can be detected.

The scientific conception of the causal relation makes the cause and its effect quantitatively equal. This quantitative equivalence between the cause and

its effect can hardly be established in our investigation. It is neglected in popular enquiry and this neglect is the spring of many of our striking fallacies. For establishing this quantitative equivalence we should see whether the phenomena treated as cause and effect vary correspondingly, When one varies and the other remains constant or when the two phenomena vary in quite different manners there cannot be any quantitative equivalence between them and so there cannot be any causal relation between them. This corresponding variation of the cause and its effect is due to the transference of energy from the cause to the effect and their quantitative equivalence. It is on account of this transference and transformation of energy that changes take place in this world and events are produced. This quantitative equivalence destroys the barrier existing between the cause and its effect and thereby makes the cause merge into the effect. Thus according to the scientific view the effect is nothing but the cause transformed; the cause and the effect are not two different things, they are rather the two aspects or two stages of one and the same thing.

According to Bain the Law of Causation implies that "in every change there is uniformity of connexion between the antecedents and the consequents." "Every event that happens is definitely and uniformly connected with some prior event or events, which happening, it happens; which failing, it fails. The kindling of a fire follows regularly on the prior events of making a heap of combustibles and

applying a light." This Law of Causation "denies pure spontaneity of commencement". It also "denies that events follow one another irregularly, indiscriminately or capriciously." "In short, the law is the statement of uniformity in the succession of events" (Bain: Induction pp. 15-16). All these explanations suppose the idea of dependence or production without which the Law of Causation can neither be understood nor explained. "The notion of cause being the root of the whole theory of Induction, it is indispensable that the idea should, at the outset of our inquiry, be, with the utmost practicable degree of precison, fixed and determined." (Mill : *System of Logic* – Bk III. Ch V Sec. 2). But it is very difficult, if not impossible, to convey an accurate idea of causation and without presupposing this very idea of causation and without introducing the notions of production, origin, and dependence which all follow from the notion of causation.

In Logic the problem of causation is equivalent to finding out the marks or signs by which a causal relation can be detected and established. In metaphysics the problem of causation is identical with an inquiry into the nature of the cause, i. e., whether it is a thing, phenomenon, force, matter, or reason. In Psychology the problem of causation is identical with the problem of the origin of the idea of Causation, i. e., how we get at the idea.

2: The Scientific or Logical view of Causation. When two facts or phenomena are causally related

to one another one of them is the antecedent and the other is the consequent. This antecedent is called the cause and its consequent is called the effect. Thus the cause is relative to a given phenomenon called its effect. We know already that cause and effect are relative terms and are therefore organically connected and so one of them cannot exist apart from the other. There is not a set of things known as causes and a set of things known as effects. One and the same phenomenon may be treated as the cause in one relation and as an effect in another relation, e. g., hunger is the cause of appetite and it is at the same time, the effect of abstinence from food for a long time. Similarly cloud is the cause of rain while it is the effect of the condensation of 'water-vapour in the atmosphere.

The marks of the causal relation may be divided into the qualitative and the quantitative marks.

The Qualitative Marks :—

(i) The causal relation is a relation of succession between two facts or phenomena, i. e., if one fact or phenomenon is causally related to another then one will follow the other and that which follows is the **consequent** and that which precedes is the **antecedent**. We know that earthquake causes many houses tumble down. So the earth-quake happens first, and after this the tumbling down of the houses takes place.

But it is not possible for us to say when the cause ceases and the effect begins. They are differentiated from each other by some geometrical line

which has no breadth. Yet the cause implies the relative futurity of the effect and the dependence of the effect on the cause. The effect also implies the relative priority of the cause. For this reason the causal relation is always treated as a case of succession and the cause is believed to precede the effect always. But it should be remembered that the causal relation is not a case of mere sequence or succession. There is succession between 1, 2, 3, yet there is no causal relation amongst them. Similarly there is succession between sunday and monday yet they are not treated as cause and effect. Thus we see that every case of succession is not a case of causation though every case of causation is a case of succession. Causation is more than succession.

(ii) The effect is always an event, that is to say, not a new thing but a change in some thing or in the relative position of things. That which happens in time is said to be an event. So the logical problem of causation is concerned with the facts and phenomena occurring in nature. In other words the changes in the nature and relative position of the already existing natural things and the processes by means of which they are brought into existence constitute the logical problem of causation.. It has nothing to do with the problem of creation or the new beginning of things. So the logical problem of causation is strictly circumscribed by the bounds of space and time. Earth-quake, death, disease, war, storm, etc., all fall within the scope of the Law

of Causation. When this law is applied to things which are not events we commit the transcendental fallacy, a form of *Non-causa-pro causa*. There is no catastrophe of the world which is uncaused, but this does not mean that we know the cause of every catastrophe or event. The great earth-quake of Quetta will again happen if the circumstances producing it happen again.

(iii) But every case of succession is not a case of causal relation, in other words, any and every antecedent is not the cause. For succession may be variable or invariable. Variable succession is not and cannot be regarded as a mark of causal relation, e. g., the barking of a dog may or may not follow or precede the falling of a picture, so the one cannot be causally related to the other. A case of succession in order to be causal must be *invariable* in character. This follows from the Uniformity of Nature which tells us that the same cause is always followed by the same effect. The case of invariable succession is best seen in the following cases :—the sun and its light, poison and death, the application of heat to a metal and the expansion of its volume.

(iv) But even invariable succession is not a sure mark of causation. For we know that day is always followed by night yet day is not the cause of night. Invariable succession, in order to be causal in character, must be *unconditional,* i. e., the invariable antecedent by itself and without taking the assistance of any other thing must be able to produce the consequent. In the previous example

day by itself and without the help of the sun and the rotation of the earth cannot produce night. So it is not an unconditional antecedent and is not the cause of night. For the same reason the flash of light which invariably precedes the report of a gun is not its cause and the death of rats which invariably precedes plague is not its cause. The unconditionality of the cause shows that there is a necessary connection between the cause and its effect and so when the cause is present the effect must be present, when the cause is absent the effect must be absent, when the effect is present the cause must be present and when the effect is absent the cause also must be absent. Thus the cause is the self-sufficient circumstance whose presence makes the effect and whose absence arrests it.

According to **Hume** the cause is simply the invariable antecedent. According to this definition sunday becomes the cause of monday, youth becomes the the cause of old age, winter becomes the cause of spring, the fall of mercury in the barometer becomes the cause of storm as there is invariable succession in each of these cases. But as a matter of fact no one of these pairs can be treated as cause and effect. For this reason Mill has abandoned the empirical interpretation of the causal relation as a case of invariable succession and has introduced the notion of production in it by adding the word unconditional to Hum'e definition of the cause. As a definition Mill's definition is also objectionable, because (i) the word unconditional makes the definition negative,

(ii) condition is a synonym of the cause and production is a synonym of causation. So this definition is not only negative but it involves the fallacy of *petitio principii.* The idea of the cause is so very fundamental that no definition of the cause can be free from this fallacy of *petitio principii.*

(v) The cause is the **immediate antecedent,** i. e.. there is no interval of time between the happening of the cause and the happening of the effect. So a remote antecedent cannot be scientifically treated as the cause. This characteristic follows from the unconditional characteristic of the causal relation. If an invariable antecedent is unconditional there is no reason why it shall have to wait for the production of its effect. When there is an interval of time between an antecedent and its supposed effect, the antecedent cannot be treated scientifically as the true cause. But when the cause and the effect are progressive or accumulating then there might be some interval between one part of the cause and another part of the effect and a part of the effect may precede a part of the cause. The accumulation of savings makes a man wealthy. But a praticular case of saving is due to industry and economy, Once a saving is made another fresh effort in industry and economy is needed for making another saving. Thus one saving may be followed by industry and economy. But there must be invariable sequence between the corresponding factors of the progressing cause and the accumulated effect.

Thus qualitatively the cause is the invariable, unconditional, immediate antecedent of a given phenomenon which is called its effect.

The Quantitative Marks :-

Quantitatively the amount of energy in the cause is equal to the amount of energy in the effect. According to the quantitative view the cause does not simply precede the effect but also produces it. The effect is not different from the cause—it is the cause transformed. The effect is no doubt different from its cause in *from* but with respect to its *matter* there is no difference, as for instance, ice appears to be different from the water out of which it is manufactured. yet with respect to its matter it is exactly identical with the water out of which it has been made.

But it is very difficult to prove this quantitative equivalence between the cause and its effect. So Logic insists that in order to establish a causal relation between two phenomena we should show the transference of energy from the supposed cause to its effect. When the transference of energy cannot be proved, the causal relation established by us remains doubtful in character.

This transference of energy from the cause to its effect cannot be satisfactorily proved in many cases. So Logic requires that before establishing the causal relation between two phenomena we should prove that there is corresponding quantitative variation between the supposed cause and its effect. In other words if one of them is made to vary

quantitatively the other will vary quantitatively and must not remain stationary, if there be a causal relation between them. If one varies and the other remains constant there cannot be any causal relation between them.

This quantitative aspect of the causal relation follows from the doctrine of the Conservation of Energy. According to this doctrine we believe that every thing or phenomenon of this world has been evolved out of energy and is an embodiment of energy. But the sum total of energy of this universe is always constant. It does not increase nor does it decrease. But energy can be transferred from one place to another and one kind of energy can be transformed into another kind of energy. In this process of transformation and transference work is done, event is produced and changes are brought into existence, but no amount of energy is lost. In the power house electrical energy is manufactured. This energy is transferred from the power house to the various street lights and to many residential quarters and there it is trasformed into light and movement of fans. Again the energy of the food taken by us is transformed into blood and muscles. When we ride on a bicycle, this energy of our blood and muscles is transformed into the motion of this bicycle. Similarly energy stored up in petrol is changed into gas and the energy of this gas is changed into the movement of the motor car.

Thus quantitatively the causal relation implies

(i) that the quantity of energy in the cause is equal to the amount of energy in the effect;
(ii) that the effect is nothing but the cause transformed—it is identical with the cause with respect to its *matter* though different in *form*;
(iii) that the cause does not simply precede the effect but produces it;
(iv) that the energy is transferred from the cause to its effect;
(v) and that any variation in the cause will imply a corresponding variation in the effect.

Thus combining the qualitative and the quantitative marks of the causal relation the cause is said to be the invariable, unconditional and immediate antecedent of a given phenomenon which is called its effect and is quantitatively equal to it.

3. **The Rationalistic view of causation.** The rationalistic logicians maintain that the cause is not the phenomenal antecedent but a noumenal agent, energy, force or power which produces the effect. The empirical or the nominalistic view reduces causation to a form of succession whereas the rationalistic view holds that causation can never be identical with any form of succession, and in order to understand the principle of causation we must suppose an inner force or power producing the effect. The inner power under the influence of some circumstances brings into existence some effect or phenomènon which we call its effect. Thus according to this view some force or energy passes out of the agent which we call the cause and enters into an object and transforms it in a peculiar way

which transformation is called the effect. Thus according to this view the cause is not that which precedes but that which produces the effect. Moreover according to this view the cause rather co-exists with the effect and the causal principle means that every event is due to a power sufficient for the purpose and not that every event is preceded by an invariable event, and that there is a bond of necessity between the cause and its effect.

4. **Hume's view of Causation.** Hume maintains that the rationalistic view of causation is not based upon perception and inference based upon perception and as such must be rejected as fictitious. In all forms of causation we can experience only succession and not production. We cannot observe any force or power passing or doing any work or producing any effect. So Hume maintains that the notion of production or transference of force or power or energy is only a matter of assumption and causation is identical with invariable succession. Hume also says that experience does not give us any idea of necessity, and so causation cannot imply necessity as it is derived from experience. His view is also called the nominalistic or the empirical view of causation. Hume's doctrine of causation has been analysed into the following elements. According to his view reality is merely a succession of sensuous impression or phenomenon and causation is the idea of invariable succession in our sensation and so it is a form of expectation only. This idea is derived from repetition in experience of some

definite individual sequence. Thus according to Hume causation is nothing but a feeling of expectation due to custom.

The hollowness of Hume's view has been pointed out by Kant. The very fact that experience does not give us any idea of necessity shows that causation cannot be derived from experience because causation implies necessity. "According to Kant Causality is a structural necessity of our mental constitution". It is a form of thought and as such it makes thinking and experience possible.

According to the Pragmatists Causality is a postulate. It is neither derived from experience nor from the necessity of reason but from postulation All axioms are really postulates at their root. When a proposition is sufficiently verified in use, i. e., when we can utilise it in our work (pragma) in a sufficient number of instances then it is accepted as true, i. e., it becomes a postulate Causality is workable and so it is real.

5. **Aristotle's analysis of the Cause.** According to Aristotle the cause contains within it four factors which conjointly act in order to produce the effect but separately they cannot exist nor can they do any thing whatsoever. Each of these factors is called a cause but strictly speaking it can be called only a condition because independently it cannot produce the effect. Now these four factors are known as (1) the material cause, (2) the efficient cause, (3) the formal cause, and (4) the final cause. Now we may explain these factors by taking an example such as

a table. The wood of the table is its material cause, the energy of the carpenter is its efficient cause, the pattern or model in the mind of the carpenter, i. e., the shape of the table is its formal cause and the end, i. e., the profit of the carpenter and the utility of the table is its final cause. Without wood the table in question would not have been made and without the energy of the carpenter the wood would not have been shaped into a table. So the wood and the energy of the carpenter are both necessary for bringing that table into existence. Unless the wood is given the shape of a table the table in question will not be made. Hence the form of the table is equally necessary. The carpenter would not have spent his energy in making the table had there been no profit in the matter, and the table would not have been made had it been completely useless. Hence without the final cause the table would not have been made. Thus all these causes are equally necessry for the table. Scientifically this analysis is wide, because our mental images or forms of objects in the mind of a person and the purpose or final cause can hardly be made the subject matter of measurement, observation and experiment and consequently they are neglected in science. So the scientific view of causation is based on the remaining two factors, namely, the material and the efficient cause. From the logical standpoint all the causes of Aristotle are not causes but conditions because no one of them can independently produce the phenomenon in question.

6. **The Principle of Ground and Cosequent : Causa essendi** and **Causa cognoscendi : the Cause** and **the Because** : The cause of the existence of a phenemenon is called its *causa essendi.* In other words the agents and circumstances which actually produce a phenomenon constitute its *causa essendi* while the cause of our knowledge of the existence of a phenomenon is called *causa cognoscendi*, i. e., the reason on account of which we believe that a particular thing will happen is called its *causa cognoscendi.* In many cases *causa cognoscendi* is identical with the *causa essendi* but in many cases they are different. As for instance while travelling in a train if we see the signal set against the train we at once know that the train will stop. Hence that signal is the *causa cognoscendi* of the stopping of the train but the *causa essendi* is the application of the brake by the driver of the engine.

The *cause essendi* is called by the name cause and the phenomenon produced is called effect, while the *causa cognoscendi* is called ground and the phenomenon which is known to happen is called its consequent. Thus the law of causation gives rise to the **principle of ground and consequent.** When the ground is fully stated or defined it becomes identical with the cause. If we refer us to the railway mechanism and the arrangement of the signals and the instruction to the drivers it will be clear to us why the driver applies the brake and stops the engine when the signal is set against

him. All these really constitute the ground of our knowing that the train will stop, These also constitute the total cause of the stopping of the train. When the cause of our true knowledge and the real cause of a thing are stated completely it will be found that thay are one and the same.

The principle of ground and consequent implies that every judgment or inference, whether deductive or inductive must be based upon some ground or reason. This principle negatives all dogmative assertion and criticism. It is often extended to cases of existence and then it implies moreover that every fact or phenomenon of this world is grounded on some adequate agents and circumstances and it cannot happen by chance. Thus this principle governs both reality and knowledge. As reality and existence cannot be thought of and understood apart from knowledge and as we are concerned with the knowledge of existence, i. e., existence and reality as interpreted by our mind so we are more concerned with the principle of ground and consequent than with the law of causation which is mainly concerned with reality as such apart from our knowledge of reality. Both these principles are assumed in all reasoning and so they are called the formal grounds of Induction, nay of all reasoning. We should remember that the ultimate ground of all knowledge and existence is the entire system of the universe.

The ground is called the reason or Because and often a distinction is drawn between the cause and

the Because, one having reference to reality and the other having reference to knowledge. Thus ground, reason and Because mean the same thing. When the ground is fully stated we can infer the consequent from the ground and vice versa. But when it is partially stated it cannot be so inferred. When all the essential conditions are set forth we have an instance of a perfectly defined ground but when they are stated only in part we have only an incomplete ground. In such a case we cannot infer the consequent from the ground nor the ground from the consequent. Having this in mind it has been remarked that every Cause is the Because, but every Because does not appear as a cause. Cause implies sequence, but Reason does not. Cause and the ground cannot be distinguished at the perfect stage, i. e., when they are fully defined. Complete cause like the complete ground corresponds to a Hypothetical judgment whose antecedent and consequent are reciprocal. (Welton).

7. **Cause and Condition.** A cause is that which is required in its totality for the production of its effect. It is generally a very complex thing containing within it many factors each of which is called a condition. Thus a condition is only a part or factor of a cause the help of which is required for the production of the effect. If any one of these factors be wanting the effect in question will not be produced. Thus any thing which helps, destroys, or retards an effect is called a condition.

The sumtotal of the conditions constitute a cause. If **A, B, C, D** are all required for the production of the effect **x** then **A** is a condition of **x**, **B** is also a condition of **x** and so are **C** and **D**. But **A, B, C** and **D** together and not separately constitute the cause of **x**. Similarly we know that the combination of hydrogen and oxygen in some definite proportion causes water. So hydrogen is a condition of water and so is oxygen. These two conditions together with their definite proportion constitute water.

Positive and Negative Conditions. A positive condition is that which cannot be omitted without affecting the effect, i. e., without prejudice to the effect. If we omit a positive condition the very same effect will not be produced. So the presence of the positive conditions is always necessary for the production of the effect. Whereas the negative condition is that which cannot be introduced without affecting or frustrating the effect. Therefore a negative condition is that whose absence is necessary for the production of the effect. If it be present the effect will not be produced and so it is a condition which must remain always absent. Supposing a picture is hanging from a wall. We cut its string and the picture falls to the ground. Now the effect here is the falling of the picture and the cutting of the string is a positive condition, because if it be not present the picture will not fall. Another positive condition is gravity. Any support other than that of the string is a negative

condition as it must remain always absent to make the picture fall. If it be introduced, i. e., if the picture be supported by things other than the string then the picture will not fall even if the string is cut. We may note here that the cause of the falling of the picture consists of the cutting of the string, the gravity of the earth, and the absence of any support other than the string. Thus we find that a cause is nothing but the assemblage of the positive and the negative conditions of the effect—the positive ones being present and the negative ones being absent. There is some objection against the description of the cause as the *assemblage* of the positive and negative conditions or the *totality* of the positive and the negative conditions. The words 'assemblage' and 'totality' imply the presence of all the factors assembled or totalled. Hence the absence of the negative conditions is not expressed by the expressions assemblage or totality of conditions.

8. **The Composition of Causes and the Intermixture of Effects.** When the separate effects of several causes become mixed together in such a way that neither of them can be directly detected in this mixture then we have an instance of the intermixture of effects. When several causes co-operate, i.e., aid or counteract upon one another so as to produce one joint effect then they give rise to combination of causes, sum of causes, or more correctly, composition of causes. The separate effects of each of these co-operating or counteract in

causes (more correctly conditions) mix together in such a fashion that they give rise to a joint effect, i.e., an intermixture of effects in which the separate effects cannot be distinguished at all. . Thus the composition of causes invariably implies an inter·mixture of effects. When the conditions and their effects which are mixed together in the above mentioned way are of the same kind we have a **homogeneous intermixture of effects,** e.g., when two or more forces acting at a point produce a resultant force we have an instance of a homogeneous intermixture of effects as the resulting force and the acting forces are of the same kind. They differ only in degree. In a tug of war also we find homo·geneous intermixture of effects. This kind of intermixture is also described as **the mechanical intermixture of effects.**

But when the joint effect and the operating conditions or composing causes are of different kinds or nature we get an instance of **heteropathic intermixture of effects.** As for instance when we mix hydrogen with oxygen in some definite proportion we get water if an electric current is passed through the mixture. But this water is utterly different from hydrogen and oxygen. So water is an example of the heteropathic intermixture of effects. Similarly blood which is utterly different from the food taken by us is an instance of the heteropathic intermixture of effects. Mental and biological phenomena illustrate this kind of intermixture. Such an inter-

mixture is also described as **chemical** or **heterogeneous intermixture** of effects.

9. **The Popular view of Causation.** Though scientifically and logically a cause is the sum-total of the positive and the negative conditions yet ordinarily in practice we neglect the negative conditions altogether, and do not consider all the positive conditions even; but we consider popularly only that condition which appears to be novel and attractive, and take that single condition to be the cause of the entire effect. Thus when a man slips and falls to the ground, we say that his slipping is the cause of his fall. But in fact slipping is only a condition. Gravity is really the most important condition of the fall, but from the popular point of view it is entirely neglected. The plain man generally neglects the collocation and identifies the cause with only the inciting power. The popular cause is sometimes described as the **occasion**. Popularly the cause is not regarded as the immediate antecedent. The plain man will say that a man takes poison first and death follows at a longer or shorter interval and so the poison is the cause of the effect death. But here the words cause and effect are used arbitrarily. By cause is meant the beginning of a chain of sequent events and by effect one of those events selected because of its arbitrary character. But in some cases the plain man does not place importance upon any sequence whatsoever, e.g., he would grant that the contact with water wets at the very moment of the contact

and that the weight of the atmosphere and the height of the mercury balanced by it in the barometer are synchronous and not successive. (Welton).

10. **The Collocation and the Moving or the inciting power.** For the production of an event we do not require simply an amount of energy but also a set of circumstances for the transference of this energy from one place to another and also for its transformation. Now the energy required for the production of a phenomenon is called the **moving power**, while the circumstances needed for its transference and transformation is called its collocation, e. g. , the petrol used in the motor car is the moving power and the machinery of the engine and the car which transfers and transforms the energy of the petrol is called the collocation. The combination and co-operation of the two are necessary for the production of the phenomenon, namely, the motion of the car. It was **Bain** who analysed the cause into the moving power and a collocation or arrangement of circumstances. These two factors of the cause make up the real cause and it is only by ellipsis or omission that one is viewed as the entire or sole cause of the phenomenon called its effect. They cannot independently produce the effect. When a demagogue by making a speech stirs up a mob to a riot, the speech is the moving or inciting power and the mob already in a state of smouldering passion and a street convenient to be wrecked are the collocation. These together make up the cause of the riot. When again a small quantity of poison kills a man

the poison is the moving power and the nervo-muscular system and the organs of the body constitute the collocation. It is only by ellipsis that the speech and the poison are considered to be the cause of the riot and death. Hence when we find that great events spring up from trivial things, i. e., when sufficient energy cannot be found in the inciting power to account for the effect we must look for it in the collocation which is often erroneously supposed to be passive. Collocation contains within it energy and force, and acts on the moving power and helps it in producing the effects Therefore collocation is active like the moving power though it is not visibly active.

Sometimes collocation is viewed as the cause of a phenomenon, e. g. the eclipse is produced by the collocation of the sun, moon and the earth. Again the moving stream is neglected and the hydraulic press to which the power of the stream or water is transferred is considered to be the cause of the work done in the press. An effect also may appear in the form of collocation as in the case of a building which is nothing but the collocation or arrangement of the materials used in the building.

With regard to the distinction beween collocation and moving power Mill has pointed out that as the cause of an event cnnsists of objects and circumstances and as objects have forces in the form of properties or qualities the so called inciting power is included within the definition of the cause and any

special mention of it is not only unnecessary but tautological.

11. **Potential Energy** and **Kinetic Energy.** Potential energy is the energy of a thing in position whereas kinetic energy is the energy of a thing in motion. We have potential energy in our muscles, but we spend kinetic energy when we strike a person. Here the potential energy of the muscles is transformed into the kinetic energy. Petrol, water, coal, etc. , have all potential energy, whereas the running engine, the running car, stream, a pendulum in motion display kinetic energy. A railway engine at a station exhibits potential energy, but when it is in motion it exhibits kinetic energy. Things which are visibly inactive possess potential energy.

12. **Force.** Force is almost identical with kinetic energy and moving power. It is better to identify it with energy, for it is really the capacity of a thing to do some work. Force has also been defined as matter in motion, and events are brought into existence by the forces exerted by objects. But this explanation of force will exclude all non-material phenomena from the category of causation, for according to it there is no causation unless there is an inciting power or force and there is no force unless there is matter in motion. Therefore there is no causation unless there is matter in motion. This will surely exclude all mental phenomena and will unduly limit the scope of the principle of universal causation. (Dr. P. K. Ray). Hence to be

consistent we should abandon the mathematical definition of force and should identify it with energy.

13. **Tendency.** When a cause consists of two or more factors, conditions or forces we may consider what effect any one of them would have produced if it operated alone, that is to say, its tendency. Thus tendency may be defined as the ability of a condition when taken by itself to produce an effect. The two ends of a bow pull at the string of the bow in the opposite direction without producing any visible effect. So their effects seem to be frustrated or annahilated. But the effects cannot be frustrated or annahilated. They remain in the from of a tendency and they become visible as soon as the connteracting forces are removed. As soon as the string of the bow is severed we find the effect of the pull exerted by the two ends of the bow. Similarly the effect of gravity on a punkha becomes manifest as soon as the cords hanging the punkha are cut.

When two forces act upon a rigid body in different directions then each of these forces has got a tendency to move the body in its own direction. Thus the separate effect of each of these forces when they act independently of each other is the tendency of that force. This is illustrated in the parallelogram of forces. Sometimes separate tendencies of combined forces may be theoretically distinguished as in the case of a projectile which we know is subject to two forces, viz., one makes it tend to travel in the straight line of discharge while the other makes

it tend to fall straight to the ground. This theoretical separation of the different tendencies is technically called **Resolution.** Sometimes a tendency may be physically separated or isolated, e. g., when a feather is dropped it is found to drift to and fro before coming to the ground. This is due to the tendency of gravity to drag it to the earth and the tendency of air to resist its motion to the earth. Now if the feather be dropped in a vacuum it will fall to the ground in a straight line just like a piece of metal. Here the tendency of air to resist the motion of the feather has been isolated physically. This kind of physical isolation is technically called **Elimination** of the counter-acting circumstances.

14. **Resultant, Counteraction and Tension :**

Resultant. When a cause consists of two or more conditions or forces then the total or net effect of all these forces or conditions is called their **Resultant.** Thus resultant is the net effect produced by the combination of the separate tendencies of all the conditions forming the cause. Thus in a parallelogram of forces the diagonal represents the resultant of the forces acting upon the body.

Counter-action. By counter-action we mean the modification of the tendency of one force or condition by the tendency of another force or condition. A tendency may be counter-acted either partially or wholly. When two equal and opposite forces act upon a rigid body it remains in equilibrium as the tendency of one force is wholly counter-acted

by the tendency of the other. But no tendency can be destroyed or suspended Hence forces are said to be in **equilibrium** when they balance one another and no motion is produced as in a tug of war when no party can move the other in any direction. In other cases the tendency of one force is only partially modified by the tendency of other forces. Thus counteraction is nothing but a form of the modification of forces. When two or more forces act upon one another in the same direction they are said to co-operate with or aid one another as their effects become added to one another and become consequently increased.

Tension. By Tension we mean the force that is exerted upon a body with the help of a rope or string. This force is equal in every part of the rope or string. Tension is sometimes identified with tendency.

15. **Mutuality of Cause and Effect and Reciprocity.** We find in our experience that industry produces wealth and also wealth produces industry. Similarly drunkenness produces poverty and poverty produces drunkenness. Similarly the more the poverty the more the number of children ; and the more the number of children the more is the poverty. All these are instances of the mutuality of the cause and effect. If two events are so related that each of them is capable of producing the other then there is a mutuality of cause and effect between them.

In Logic there cannot be any mutuality of such

a nature between a cause and its effect, because such causes and effects are antecedents in some cases and consequents in other cases. Hence no one of them can be treated as the invariable antecedent. For this reason the mutuality of cause and effect is treated as a fallacy in Logic, and events related to one another as mutual cause and effect are considered to be false causes and effects. But there is a kind of mutual relation between the cause and its effect which is recognised in Logic. If there be no effect there cannot be any cause and if there be no cause there cannot be any effect. A is called the cause because it produces the effect x. Hence the existence of the effect x is the reason on account of which the cause is called a cause. Hence the effect is called the because or reason of the cause.

From the quantitative standpoint there is every justification for accepting the reciprocal relation between the cause and its effect. Every instance of causation becomes reciprocal when the conditions are fully known. If X be the total cause of y and if y be the total effect of X then X can be transformed into y and y also can be transformed into X. We know that hydrogen and oxygen mixed in a definite proportion always produces water. This water again can be resolved into the same quantity of hydrogen and oxygen. This follows from the equality of cause and effect and the principle of the conservation of energy. If the effect is nothing but the cause transformed there is no reason why

the cause cannot be produced by the effect or in other words why the energy found in the effect cannot be re-transformed into the cause. But as we cannot fully ascertain all the conditions of an effect the reciprocal relation remains an ideal only. In most of the cases of causation we cannot re-transform the effect into its cause. In physiological actions this ideal relation of reciprocity cannot be established, e. g., food becomes converted into blood but blood cannot be re-transformed into food. But this is due to our ignorance.

Carveth Read opposes the mutuality of cause and effect.

Carveth Read is strongly opposed to the doctrine of the mutuality of cause and effect. He says, "We should not think that the effect can also produce the cause or that the cause follows from its effect just as the effect follows from its cause for as the effect arises its cause disappears and is irrevocable by Nature and Magic." According to Carveth Read the mutual relation existing between the separate conditions or their tendencies is called reciprocity or mutual influence. The total effect is produced by this reciprocal relation, i. e., the several conditions constituting any cause jointly determine the total effect by aiding or counter-acting one another's tendency. This reciprocity exists only between the factors of a cause. But we should not extend this relation to a cause and its effect.

He, therefore, uses mutuality in a different sense.

Sometimes by mutuality the law of reciprocity is meant.

Sometimes by mutuality or reciprocity the Law of Reciprocity is meant. This law is just the reverse of the Uniformity of Nature which says that the same cause produces the same effect, while the Law of

Reciprocity tells us that the same phenomenon is always produced by the same cause. Thus we see that mutuality has been differently explained by different logicians. This becomes invariably the case whenever a popular word is adopted in scientific investigation.

16. **Agent, Patient and Inertia**. Agent is a person or thing that exerts force or power. In other words that which is visibly acting is called agent. By patient we mean a person or thing which is acted upon by the agent, i. e., upon which force or power is exercised, e. g., when I move the table I act on the table and so I am the agent of the movement of the table, whereas the table is called the patient as it is acted upon by me. But nothing is absolutely an agent or absolutely a patient for we know that every action has its equal and opposite reaction. When I strike upon the table, the table also reacts on me and so I feel pain in my fist. Hence it is also active like me. Hence the two terms are relative. Where activity is prominent we use the term agent, and where passivity is prominent we use the term patient. Hence the moving power is the agent while collocation is the patient.

Inertia. By inertia we mean the inherent property of matter by which it tends to remain for ever at rest while still, and in motion while moving. Inertia does not mean want of vigour or activity but the exact contrary. It may be defined as the re-

solve, determination or tendency of everything to have its own way.

Co-effect and Joint effect. When two or more separate effects are produced by one and the same cause then these separate effects are called **co-effects.** These co-effects may be successive or simultaneous, e. g., night and day are the successive co-effects of the rotation of the earth on its axis in the presence of the sun, while the light and heat which we find in the rays of the sun are the simultaneous co-effects of the sun. Similarly the flash of light and the report of the gun are the successive co-effects of the explosion of gun-powder in a closed chamber. The death of rats in a large number and the outbreak of plague are the co-effects of the biting of a kind of flea. It is a fallacy of *non causa pro causa* when one of the co-effects is viewed as the total effect or when a co-effect is treated as the cause of the other.

$$\begin{tikzcd} & A \arrow[dl] \arrow[dr] & \\ x & & y \end{tikzcd}$$

......Co-effects of A.

Joint effect. When two or more agents interact their separate effects are mixed together so as to give rise to a complex phenomenon. In this complex phenomenon the separate effects cannot be detected. Such a complex phenomenon illustrates oint effect. When two persons move a block of stone

the movement of the stone illustrates joint effect as in it the separate effects of both the persons are blended together in such a fashion that one of them cannot be distinguished from the other. The co-effects remain distinct from one another but in the joint effect the separate effects of the combining causes are blended together in such a manner that they lose their separate existence. The joint effect can be symbolically represented in the following manner :—

$$\begin{array}{c} A \text{——} B \text{——} C \\ \downarrow \\ x\ldots\ldots \text{Joint effect} \end{array}$$

18. **Progressive effect.** When an effect requires a considerable amount of time for its happening and comprises within it the accumulated effects of many agents and circumstances it is called a Progressive effect, e. g., revolution is due to the accumulated results of many causes. Similarly wealth, character, civilization, war, wisdom, etc.. are due to the accumulated effects of many causes occurring at different periods. In an effect like this we find that on account of this accumulation, the original effect progresses, develops or grows more in intensity and magnitude. So it is called a progressive effect.

19. **Proximate and Remote Causes.** From the popular point of view causes are divided into two clases, namely proximate and remote. The condition which happens immediately before the

effect is called the **proximate, immediate** or **direct** cause, while the condition which happens long before the effect is called the **remote, mediate,** or **predisposing** cause, e. g., the cutting of the string and good rain are the proximate causes of the falling of the picture and good harvest respectively. Similarly the correct answering of questions is the proximate cause of the succeess at an examination. While gravity, cultivation, fertility of the soil, sowing, etc , and good preparation are the remote causes of the falling of the picture, good harvest and success. Again if A produces B, B produces C, and C produces D, then C will be the proximate cause of D, and A and B will be the remote causes of D. Cat destroys mice, mice eat up the nests of bees and bees fructify clover. Therefore the proximate cause of clover crop is the fructification of clover by the bees and the remote cause of the clover crop is the existence of cats.

20. **Intrinsic and Extrinsic Causes (more correctly conditions).** If with the cessation of a cause the effect also ceases to exist then the cause will be called an **Intrinsic Cause** or condition. But if with the cessation of a condition the effect does not cease to exist then the condition will be called an **Extrinsic Cause** or condition. The carpenter and his instruments and the purpose of the carpenter are the extrinsic causes of the table manufactured by him, and the plank and the form or shape of the table

are the intrinsic conditions of the table. Thus the final and the efficient causes of Aristotle are extrinsic in nature while his formal and material causes are intrinsic. The potter is the extrinsic cause and the clay used by him is the intrinsic cause of the pots made by him with this clay. Similarly the thread of a piece of cloth is its intrinsic cause while its maker, the weaver, is its extrinsic cause. Modern logicians have altogether abandoned the extrinsic causes by maintaining that the effect is nothing but the cause transformed. The carpenter in question is not the real cause of the table manufactured by him. It is the amount of energy lost by the carpenter in making the object and the energy lost by the tools of the carpenter together with the planks used constitute the object. This energy transforms the plank into a table and lives in the table. Therefore the cause cannot live outside of and apart from its effect.

21. **The Plurality of Causes, the Vicarious or Alternative Causes.** In our experience we find that one and the same event is produced independently by different causes, e. g,, illness is caused by malaria, influenza, cholera, etc. Light is caused by the sun, the moon, the stars, electricity, gas, etc. Similarly death is caused by burning, drowning, poisoning, etc. If we find that **x** can be produced by **A** in one occasion, by **B** in another, and by **C** and **D** on other occasions then we have a plurality of causes capable of producing **x** independently. This

can be symbolically represented in the following way :—

$$\begin{array}{cccc} A & B & C & D \\ \downarrow & \downarrow & \downarrow & \downarrow \\ x & x & x & x \end{array}$$

Here in different times and at different places x is being produced by different agents. Hence we have a plurality of causes for x.

Hence by the doctrine of the plurality of causes we mean that one and the same event can be independently and separately produced by different causes or agents. This doctrine has also been described as the doctrine of the **Vicarious or Alternative Causes**

Eeffect of this doctrine on inference. The inductive problem is of two kinds, namely (1) a phenomenon may be given and we may be required to find out its cause, or (2) some agent may be given and we may be required to find out its effect. Thus induction considers two kinds of inference, viz., the inference of the cause from the effect and the inference of the effect from the cause. Now if we accept the plurality of causes the inference of the cause from the effect will become impossible because it cannot be said for certain which one of the plurality of the causes is producing the phenomenon in question. If **A**, **B**, **C**, and **D** be the different causes of x and if x be given to us we cannot say for certain whether it has been produced by A or B or C or D. Thus only one kind of inference will remain open to us in induction. In other words the plurality of causes

allows us to proceed from the cause to the effect but not from the effect to the cause.

Though the plurality of causes is a popular doctrine yet this limitation of inference by this doctrine is overlooked in practice. When we see a particular light we can say, i. e., infer, whether it is being produced by the sun or the moon. In the post mortem examination the doctors proceed from the effect to the cause. Similarly when a person falls ill he infers that his illness is due to some thing, say exposure.

Accuracy of this doctrine. Scientifically the doctrine of the plurality of causes is untenable, because according to the scientific view of causation, the cause is the invariable antecedent of its effect. But according to the doctrine of the plurality of cases the cause becomes a variable antecedent. In the symbolical example mentioned above x is preceded by A in some cases and by B, C and D in other causes. Hence A, B, C and D which are treated as the causes of x according to the doctrine of the plurality of causes are variable antecedents of x. Besides according to the quantitative view of causation there is no difference between the cause and its effect with regard to **matter**—there is difference only in **form.** The effect is nothing but the cause transformed. This also tells us that one event can have only one and the same cruse and not a plurality of causes. Thus the doctrine of the plurality of causes is neither tenable nor compatible with the scientific view of causation.

Though theoretically we reject the doctrine of the plurality of causes yet in practical investigation in logic and science we always accept this doctrine and see whether our inference is vitiated by the plurality of causes. If one phenomenon is capable of being explained by different causes separately then no one of these can be treated as the true cause of the phenomenon. In the inductive investigation the conclusion which is liable to be vitiated by the plurality of causes remains always probable. So logicians try their level best in getting rid of the plurality of causes.

In practical investigation we always try to remove the plurality of causes.

The Method of the elimination of the plurality of Causes. There are two methods by which the plurality of causes can be eliminated, viz., the generalisation of the causes and the specialisation of the effect.

The plurality of causes is eliminated by the generalisation of causes or the specialisation of the effect.

(i) **The Generalisation of the Causes.** This consists in first of all analysing all the different causes into their constituent parts and attributes and then comparing the constituent parts and attributes of one of the causes with those of others with a view to detect the common factors of all these causes and lastly separating these common factors from the rest. These common factors should be then treated as the true and only cause of the phenomenon in question. We know that death is caused by burning, drowning, cholera, small pox, etc. By analysing all these causes we find that the failure of the heart is present in all these causes. Hence by generalisation we treat the failure of the heart

How do we generalise the causes and ascertain the true cause.

as the true and only cause of death. Similarly light is produced by the sun, the moon, electricity, gas, etc. We find by analysis that the common factor is the vibration of ether. Hence this vibration is the true and only cause of light. Similarly the vibration of the atmosphere is the true and only cause of sound and not the various ways in which sound may be produced.

(ii) **The Specialisation of the effect**. This consists in taking the effect in question with all its individual peculiarities. If we take into consideration the special feature of the event in question we shall see that it can be produced by only one cause. We know that light is produced by the sun, the moon, electricity, gas, etc. But if we take into consideration the peculiarity of light in each case we see that the plurality of causes disappears and one event can be produced by only one cause. The bright light produced by the sun cannot be produced by any other agent. Similarly the silver light of the moon can be produced only by the moon.

Of the two methods for the elimination of the plurality of causes the second is the better. Ordinarily we do not take the cause and its effect in their totality. We treat the real cause and the circumstances in the midst of which it occurs as the cause of a phenomenon and overlook the collocation which is necessary for the transformation of the energy of the popular cause into the effect. We also view a part of the effect as the total efiect, e. g., when a person takes opium he dies no doubt,

but along with his death many physiological changes take place in his body. Similarly when a person dies of cholera or burning many changes take place in his body. These physiological changes are different in different cases of death. These physiological changes are examined by doctors at the *post mortem* examination and so they are able to infer the right cause of death in each case. This *post mortem* examination would have been impossible if the doctrine of the plurality of causes were true. Hence we conclude that it is the failure of analysis or incomplete analysis that gives rise to the plurality of causes. To safeguard against the plurality of causes we should analyse the event in question and treat it along with its special features, i. e., we should take the event in its totality.

The plurality of causes is diametrically opposed to the Law of Reciprocity which maintains that the same event can be produced by one and only one cause, while the plurality of causes maintains that an event can be produced by different causes. Thus this popular doctrine is opposed to the scientific view of causation.

When we cannot get rid of the plurality of causes in our investigation we apply the doctrine of chance and probability and thereby ascertain which of the causes is more likely to produce the effect in question, i.e., we measure the efficiency of the separate causes in producing the event in question.

22. **The Diversity of Effects.** This doctrine maintains that one and the same cause may produce different effects at different times, e.g., opium produces death in one case while in another case it cures a malady. Symbolically it may be illustrated in the following manner :—

$$\begin{array}{cccc} A & A & A & A \\ \downarrow & \downarrow & \downarrow & \downarrow \\ x & y & z & m \end{array}$$

But these are not the total effects of **A.** In all such cases the cause is quantitatively greater than the effect, i.e., there is some surplus matter and energy in the so called cause. There will be no diversity of effects if we quantify the cause and view the effect in the totality. There being a necessary connection between the cause and its effect and there being the principle of the Uniformity of Nature the same cause is bound to produce the same effect always. Hence the diversity of effects cannot be accepted from the scientific standpoint.

33. **The Relation between the Law of Causation and the Uniformity of Nature.** It is generally believed that the law of causation is different from the uniformity of nature and that the law of causation is a form of this uniformity of nature. The uniformity of nature covers within it the uniformity of succession, the uniformity of coexistence,. and the uniformity of equality or inequality, and the law of causation is a form of the uniformity of succession. The logical or the scien-

tific view of causation combines within it the law of causation which says that every event has a cause and the uniformity of nature which holds that identical things happen under identical circumstances. But Dr. P. D. Shastri maintains that the fundamental law is the law of causation and the uniformity of nature is a corollary drawn from it. Bain and Joseph also hold this view. So according to this view the uniformity of nature is derived from the law of causation and not vice versa. The very notion of causation involves the idea of uniformity. To deny this is to deny causation itself. If **x** and **y** be causally related then **x** must produce **y**. Had there been no necessary connection between them there would have been no justification for us in using the words 'must' and 'produce'. "If a cause did not act uniformly, that is to say, if the same cause under the same condition could produce a different effect, it would amount to saying that nothing possesses any determinate nature which would contradict the law of identity" (P. D. Shastri's Logic).

The Law of causation is also called the universal causation and the word 'universal' implies that the cause must operate uniformly. It is a contradiction in term to speak of a cause as not acting uniformly. Hence it is not correct to say that the law of causation and the uniformity of nature are two different things—they are rather identical and the only distinction is that the uniformity of nature is an aspect of the law of causa-

tion. The ultimate presupposition or the ground of induction is only the law of causation. It is a form of our resoning and cannot be derived from our experience. It is presupposed in all knowledge and existence and without it the universe would be unintelligible.

But this view even is not wholly correct, because we cannot get the uniformity of co-existence and the uniformity of equality or in-equality from the law of causation because this law of causation is concerned with the cases of succession only. The cause no doubt acts uniformly but it is wrong to say that uniformity always gives us causation.

What appears to be the correct view on the subject is that the law of causation and the uniformity of nature are the two aspects of the law of identity. The statical identity gives us the uniformity of nature and the dynamical identity gives us the law of causation. As motion supposes position, so causation supposes uniformity. In fact the law of causation and the uniformity of nature are connected in such away that we cannot have the one apart from the other.

24. **The origin of our idea of Causation.** There is a great controversy as to the origin of our idea of causation. There are three important views on the subject, viz., (i) the empirical view which says that the idea of causation is derived from experience ; (ii) the rationalistic view on the other hand maintains that it is not derived from experience

because experience and knowledge presuppose it. The idea of causation, therefore, is an *apriori* idea. We are born with it and do not learn it from nature through experience. (iii) The evolutionists on the other hand maintain that to our ancestors who lived long ago this idea was *aposteriori*, i. e., they learnt it from experience, but in course of time on account of evolution this idea has become stamped in the human constitution in such a way that we now inherit it along with our body and mind from our parents. Thus to us it is *apriori*. This view and the empirical view are both incorrect because experience presupposes causation and does not give us any necessity while causation implies necessity.

25. **Exercises.**

1. Write a short essay on the conception of Causality showing carefully all its implications.

2. State the Law of Causation, and show how it plays the most important part in induction.

3. State the Law of the Uniformity of Nature and the Law of Reciprocity. Do they follow from the Law of Causality ?

4. Explain and illustrate the scientific conception of causality.

5. Show how the popular and practical cause differs from the scientific cause.

6. Is the causal relation a case of mere succession? Give reasons for your answer.

7 Can there by any accurate definition of the Cause? Show how Cause is defined in Logic. Is this definition accurate?

8. Distinguish the logical problem of causation from the Psychological and the Metaphysical Problem of causation

9. Explain the various characteristics of the causal relation.

10. Distinguish between a causal and a casual phenomenon. How would you know that a case of relation is causal?

11. Explain the quantitative and the qualitative marks of the causal relation.

12. Can there be any accurate conception of causality without its quantitative aspect? Explain the basis of this aspect of causality.

13. Explain the doctrine of the Conservation of Energy. Show what part it plays in Induction. Is it proved in any science?

14. Take a concrete case of causation from your own experience and show how it possesses all the marks of causality.

15. Distinguish between the rationalistic view of causality and the empirical view of causality.

16. Explain Hume's view of causality. What are its defects?

17. Explain with the help of an example the various causes of Aristotle. Are they really causes?

18 Explain the Principle of Ground and Consequent. How is it connected with the Law of Causation?

19. Explain the distinction between *causa essendi* and *causa cognoscendi*.

20. Explain with the help of an example the distinction between the Cause and the Because.

21. Explain what you mean by the condition of a phenomenon. What are its various kinds ?

22. Explain the positive and the negative conditions of a phenomenon. Is it correct to say that the cause is the sumtotal of the positive and the negative conditions ?

23. Explain the composition of causes and the intermixture of effects What trouble is created by such an intermixture in our inductive investigation ?

24. Explain the popular view of causation.

25. Explain clearly with the help of examples the significance and function of Moving Power and Collocation. Is Collocation entirely passive ?

26. Explain Energy, Tendency, Tension, Inertia, Patient, and counteraction. Can the effect of a cause be destroyed ?

27. Exaplain the Mutuality of Cause and Effect. Is it consistent with the logical conception of causality ?

28. Explain and illustrate Co-effects and Joint effect, Progressive effect, Remote and Proximate effect, Intrinsic and Extrinsic Causes.

29. Explain the Plurality of Causes. How does it affect inductive inference ? Is it tenable ? How do we get rid of the Plurality of Causes ?

30. Show that imperfect analysis underlies the conception of the Plurality of Causes. Explain the Generalisation of the Causes and the Specialisation of the Effect. Which of them is better, and **why** ?

31. What do you mean by the Diversity of Effects ? Is it tenable ?

32. Explain the relation between the Law of Causation and the Uniformity of Nature. Show their relation to the Law of Identity.

33. How do we get the idea of causality? Is it learnt or inherited?

34 What is meant by Composition of Causes? By what form of reasoning is it possible to ascertain beforehand the effects of Composite Causes? In what sciences, and in what profession is reasoning of this kind most essential?

35. Explain the meaning of Energy and Conservation of Energy; and show the bearing of the theory on the nature of causality.

36. (i) If it be true that the same cause produces the same effect, does it follow that the same effect is always produced by the same cause? Give your reason for your answer, and support it by illustrations.

(ii) Show how the principle involved here gives rise to difficulty in drawing inferences, giving examples. How may the difficulty be overcome? Give examples.

37. What do you consider to be the difference between cause and condition? Give examples. If a workman, carrying a burden falls from a ladder and is killed, what do you consider to be the cause and the condition of his death, and why? A distinction may be made between cause from the scientific and cause from the merely practical point of view; in the above case what may be regarded as cause from the merely practical point of view?

38. A man is crossing the river in a small boat; a sudden squal of wind comes on; the boat founders, and the man is drowned. What do you con-

sider to be the cause and the conditions of his death ?

Distinguish between proximate and remote causes. Illustrate your meaning by examples.

39. What is the Law of Causation ? How may the law be best expressed ? What are the different aspects under which Causation may be viewed ? Give a concrete example of each.

40. 'It is in the comprehensive Law of Causation itself once established by induction that we have the instrument of eliminating cause and effect in detail.'

Explain this statement and illustrate it by examples.

41. Why is it that one should not regard night as the cause not even as a universal condition of day ? Explain cause and condition.

42. What do you understand by the Plurality of Causes and the Mutuality of Causes and Effects ? Illustrate your answers by examples

43. Determine the character of the Cause and deduce the Experimental Methods from the Law of Causation.

44. A balloonist, unable to make a successful parachute descent, falls headlong and dies. Determine clearly the cause and conditions of his death.

45. A man goes out into the open air where breeze is blowing and gets cold. What is the cause of his getting a cold from the practical point of view and from the scientific point of view ? Fully explain the scientific conception of Causation.

46. Explain the conception of a cause as a group of antecedents necessary to and sufficient for the effect. What is meant by a negative condition of an event ?

47. Is causal connection between A and x validly disproved :—(i) If the absence of A is followed by the presence of x, (ii) if the absence of A is followed by the absence of x ?

48. Can an effect be produced by alternate causes ? Explain and illustrate the different modes in which two or more causes combine to produce a single effect.

CHAPTER V

The Material Grounds of Induction: Observation and Experiment.

1. **Material Grounds and their Function.** We have seen that the material grounds of Induction consist of Observation and Experiment. Their function is to supply us with materially true premises so as to enable us to establish materially true conclusion. We require observation at the beginning of our investigation in order to gather particular instances to be used as premises, and also towards the end when the conclusion arrived at by induction is verified Without the help of observation and experiment the establishment of material truth becomes impossible. In Induction we are required to handle facts and appeal to facts—we are required to analyse them into their elementary factors and conditions, and lastly by synthesis we are to get at the causal basis of the phenomenon under investigation. With the help of observation and experiment we also isolate the phenomenon under investigation from irrelevent circumstances with which it remains jumbled up. Thus to create a favourable atmosphere for examining a phenomenon we require the help of observation and experiment.

2. **Observation, Experiment and Perception.** The various facts or phenomena which occur in nature affect our sense organs and we take notice of them with the help of our sense organs. This mental process of taking notice of the facts and phenomena occurring in nature with the help of our sense organs is called **Perception**. Hence in Perception facts and phenomena are presented by nature and we take notice of them with the help of the sense organs. Perception, therefore, is a process by which we receive information of the world in which we live, move, and have our being. Popularly Observation is identified with perception, but scientifically and logically methodical perception alone is identical with observation. Hence observation may be defined as methodical perception. Now Perception is said to be methodical when it is guided by hypothesis, i.e., when it aims at the realisation of certain end. Popular observation is aimless and random. When we come to the college we take notice of many things that happen by the road side, but in making such observation we have hardly any end in view, but when a doctor takes the blood of a person and examines it under a microscope in order to ascertain the number of red and white corpuscles in it he is said to make an observation. Similarly if we examine the food of a person suffering from cholera in order to ascertain the cause of the disease we are said to make an observation. Thus observation consists in taking notice of the facts and phenomena occurring in nature

with the help of our sense organs in order to ascertain a cause or to establish a law of nature.

Experiment is a higher kind of observation with this difference that in observation the facts and phenomena examined by us are presented to us by nature, while in experiment the facts and phenomena examined by us are brought into existence by our individual effort. If we produce electricity in a laboratory by moving the handle of a machine and study the nature of this electricity then we are said to make an experiment, while we are said to make an observation when we study the electricity produced by the clouds during a thunder storm. Hence experiment consists in taking notice of facts and phenomena artificially produced by us with a view to ascertain some cause or to establish some law of nature. Bain has described observation as a process of finding a fact, i.e., discovering it, and experiment as a process of making one, i.e., artificially producing it Observation and Experiment do not differ in kind, they differ only in degree, because in both of them facts happen, and we take notice of them with the help of our sense organs. But in the former they happen in the course of nature, while in the latter they are artificially produced.

It should be noticed that the use of scientific instruments will not transform an observation into experiment. If the phenomenon studied with the help of scientific apparatus happens in the course of nature then we shall be making an observation,

but if it is brought into existence artificially then we shall be performing an experiment. In dissection the doctor simply opens a body to see its internal changes which have happened in the course of nature and so the doctor makes an observation in dissection. Similarly the doctor makes an observation when he examines the heart of a patient with a stethescope or examines blood under a microscope or analyses urine with a view to detect some disease But if he prepares a vaccine and injects it into the body of a pig to see its result then he will be performing an experiment. For the same reason vivisection is a case of experiment. When a monkey gland is engrafted in the body of an old man in order to rejuvenate him we have a case of experiment. Again we have experiment when the cerebellum of a frog is removed in order to see what effect it produces on the movement of the frog.

3. Relative advantages of Observation over Experiment

(i) The scope of observation is considerably greater than that of experiment. There are many things in this world which are beyond our control. There cannot be any experiment on these objects. For this reason we cannot have any experiment on earthquake, the eclipse of the sun and the moon, storm, tides, volcanic eruption, etc. But all these things which are beyond our control can be observed. There are also many things in this world which are so dangerous that we cannot perform any experiment upon them, e.g., suicide, epidemic, famine, legislation,

etc Only a few things of this world are under our control and can be experimented upon. Sciences like history, geography, politics, astronomy depend mainly upon observation and subsequent calculation because the phenomena studied in them are either beyond our control or are too dangerous While the sciences like physics, chemistry, botany are mainly grounded on experiment because the phenomena studied in them are under our control and are not too dangerous.

(ii) In observation we can proceed from an event to its cause and also from the cause to its effect, but in experiment we can proceed only in one direction, namely from the cause to its effect but not from the effect to the cause. In the *post mortem* examination the doctors proceed from the effect to the cause, whereas in weather forecast the officer-in-charge proceeds from the cause to the effect. Similarly a police officer while investigating a case of murder or theft proceeds from the effect to the cause while a hunter proceeds from the cause to its effect at the time of shooting at a game.

(iii) Observation gives us the general peculiarities of the objects studied, whereas experiment obscures the general features of the objects studied. By performing an experiment on a flower we can hardly know its general use and feature, while by observation we get the general use of flower very easily. A knowledge of the general feature of the facts and phenomena of this world is of great practical value.

(iv) Observation constitutes the basis of experiment and without a previous observation of the facts under investigation no experiment is possible. The function of observation is to suggest a hypothesis in order to prove it later on by experiment

(v) Popular knowledge as well as knowledge required in our every day life is grounded on observation. Very few of us have the leisure and ability to acquire knowledge by means of experiment.

(vi) Observation is easier and less exacting than experiment. But unfortunately on account of this it is less reliable than experiment.

(vii) The knowledge of the superficial qualities of things is gathered by means of observation while the knowledge of the essential features is acquired by means of experiment. Both these forms of knowledge are equally necessary for the preservation and development of our life.

4. **Relative advantages of Experiment over Observation :** In experiment the conditions determining the phenomenon under investigation are completely known and are under our cntrol, whereas the conditions of the phenomenon under study in observation are obscure or partly known, and are not under our control. This knowledge of the conditions determining the phenomenon under study, and our control over them constitute the principal advantage of experiment over observation. Other advantages follow from this fundamental condition.

(i) On account of the fact that the conditions determining the phenomenon under study in

experiment are under our control, the phenomenon can be repeated as many times as we like, whereas in observation these conditions are beyond our control, so we cannot repeat the phenomenon under investigation in observation according to our desire. For the repitition of the phenomenon under observation we depend upon the bounty of nature. It may not be repeated in our life time, e.g., the great earthquake of 1934 may not happen again in our life time but we can mix hydrogen and oxygen in some definite proportion and produce water by this process as many times as we like. Again on account of the fact that the conditions determining the phenomenon under expriment are under our control it is often said that in experiment we are the master of nature. On account of the absence of this control in observation it is often said that we are the salves of nature in observation. In other words in observation we accept the phenomenon presented to us by nature and fail to repeat it or introduce any change in it or in its condition

(ii) On account of the fact that the conditions determining the phenomenon under experiment are under our control we can vary the circumstances in experiment, i. e., we can introduce new agents and eliminate some of the existing agents or conditions or we may increase or decrease the quantity of some or all the conditions determining the phenomenon. Without such a variation it is not possible for us to ascertain and prove any causal relation.

In observation, on the other hand the conditions determining the phenomenon under study are beyond our control and are not sufficiently known. So it is not possible for us to vary the circumstances according to our requirements. For their variations we depend entirely on the sweet will of nature. So the conclusion arrived at by induction from the premises gathered by observation is probable, whereas induction establishes reliable conclusion when the premises from which the conclusion is inferred are derived from experiment.

(iii) In observation we are taken by surprise and so the phenomenon dissappears before we can be ready for its study, e.g.. in the case of an earth quake we are taken by such a surprise that we can scarcely study its nature. But in experiment our attention is pre-adjusted and we definitely know beforehand when the phenomenon will take place : so we can study it more carefully in expriment than in observation But in some cases of observation our attention is pre-adjusted, as for instance, in observing the eclipse of the sun and the moon we know beforehand when it will take place. It is definitely found out by calculation when and where the complete eclipse of the sun will take place and so astronomers go to that place with their telescopes and other astronomical instruments in order to study the sun at the time of the eclipse. But very few of the astronomers can afford to take the advantage of such an opportunity. Besides in experiment we are able to study the manner

in which a phenomenon appears and disappears. But this is not possible in observation.

(iv) In experiment the phenomenon under study and its conditicns can be held before our eye as long as we disire. But the phenomenon under investigation in observation cannot be studied in that manner for it disappears very quickly, and its presence, disappearance and duration depend entirely on the sweet will of nature.

(v) Experiment gives us reliable conclusion, whereas observation gives us only probable conclusion.. If we can perform an experiment accurately and successfully then that one experiment alone is sufficient to establish a causal relation, whereas we require a large number of instances gathered by observation in order to establish a causal relation. By observation we can at most prove that an antecedent is invariable. To prove that it is also unconditional we require experiment. If, for instance, we can make the invariable antecedent artificially produce the supposed effect then and then only we can be satisfied as to its unconditionality. Thus true induction is always grounded on experiment.

(vi) Experiment reveals the essential nature of the facts and phenomena under study, whereas observation gives us only their superficial features. For this reason the experimental sciences are fast progressing in the world, while the sciences based on observation alone are hardly making any headway.

(vii) We shall see later on that the requirements of the various experimental methods on which inductive reasoning is grounded cannot be fully satisfied if the instances or premises be gathered by observation—they can be satisfied only by experiment.

(viii) Experiment also prepares the grounds for observation. The circumstances in the midst of which a phenomenon occurs in the course of nature are so complex and mixed up that accurate and minute observation is practically impossible. In experiment circumstances are artificially produced in order to enable us to observe the phenomenon under investigation calmly, minutely, and accurately. Hence H. Stephen has described experiment as experimental observation. It is therefore quite correct to say that observation makes experiment possible which we have seen before, and also experiment makes observation possible which we have seen just now.

5. **Natural Experiment.** It is a form of observation but in it the phenomenon under study is observed in the midst of various different circumtances and these variations in circumstances are not artificially produced by us but are presented to us by nature. If we study the colour of birds in the different regions of the world in order to detect whether it resembles the colour of the neighbourhood or surroundings and favours their concealment from their enemies, then we shall be making natural experiment. Similarly if we study the

eclipse of the sun at different places on the surface of the earth and in different circumstances, in order to ascertain the nature of the sun then we shall be making natural experiment. Thus natural experiment lies between pure observation and experiment. It differs from experiment because the variations in circumstances are not artificially produced but happen in the course of nature. It is really a case of observation because in it the phenomenon studied happens in the course of nature. When we talk of experiment in connection with Geography we generally mean natural experiment.

6. **The Methods of Observation and Experiment.** Tho following methods have been prescribed by Fowler for scientifically conducting Observation and Experiment.

(i) *Observation and Experiment must be precise*, i.e., in making an observation or performing an experiment we should notice "the exact time at which an event occurs, the length of its duration, the position of an object in space, its relation to surrounding objects and the like." In order to secure this end all the necessary up-to-date scientific apparatus must be used In measuring the quantity of an object we should follow the method of double weighing and the method of taking the average of our different observations. We should try our best to be scrupulously accurate and precise in our measurement and calculation. For this purpose unit is necessary because without a unit no measurement is

possible and this unit should be capable of being used in multiples and divisions. We know that in the English system pound and year are used as units for measuring material bodies and time respectively.

(ii) *In order to avoid distraction and waste of time we should attend only to the material circumstances of the case we are investigating,* i. e., we should study only the circumstances which are relevant to the subject matter of our investigation and must not confuse them with irrelevant ones. But at the initial state of our enquiry it is very difficult to distinguish the relevant from the irrelevant ones. In fact the greatest difficulty in the inductive investigation lies in eliminating the irrelevant circumstances from the relevant ones. When the relevant circumstances are found out the inductive enquiry comes to an end and the cause is found out and established.

(iii) *The circumstances in which an observation or experiment is made should be varied as much as possible in order to show that the supposed cause and the effect vary correspondingly.* It should be noticed that in induction we are not satisfied in establishing simply a causal relation between two phenomena, say A and x, we require also the additional information as to how much of the cause, A, produces how much of the effect, x. It is not sufficient for us to know that a combination of hydrogen and oxygen produces water, we must know also the definite proportion in which the two

must be mixed in order to produce it. Similarly it is not sufficient to learn that quinine cures malaria, but we must know the dose in which it must be administered to produce the result.

(iv) *"The phenomenon under investigation should, if possible, be isolated from all other phenomena, or, at least from all those which are likely to interfere with our study of it."* "A physician in trying the effects of a new drug will at first at least administer it alone and not in combination with other drugs which might augment or counteract its influence on the system." But this isolation is possible more in experiment that in observation, because the phenomenon under investigation is under our control in experiment but not in observation.

The aim of observation and experiment is the elimination of the non-causes and the determination of the causes. When we fail to eliminate these non-causes we invariably fail to establish the causal basis of the phenomenon under investigation. Hence the real difficulty of the inductive method lies in accurate observation and experiment, both of which involve analysis and elimination.

Another great difficulty in observation and experiment lies in the fact that we fail to distinguish between what is perceived and what is inferred. During the very early part of our childhood pure perception might have been possible, but in all other cases we invariably mix up inference with perception. But the inferential elements

detected by psychologists in our perception do not trouble the ordinary scientists. They treat these elements as perceptual because they are repeated so much that very easily at every step we can test them by making them the subject-matter of our perception. Besides all these inferences which are detected in observation and experiment take place below the level of consciousness. So they may be neglected in inductive investigation Yet this confusion of perceptual truth with inferential knowledge gradually gives rise to carelessness and the fallacies of observation and experiment, viz., mal-observation and non-observation. Having these inferential elements and the goal of observation and experiment in view Dr. P. K. Ray has said that "observation is the extension of immediate perception by inference and experiment is the extension of observation by special arrangements of natural objects."

(v) Over and above the methods given by Fowler we must add the following :—*At the time of making an observation or performing an experiment we must be free from bias and we must not distort facts in order to harmonise them with our theories or views.*" A good investigator must have clear notions of the result he expects and confidence in the truth of his theories, and yet he must have that candour and flexibility of mind which enable him to accept unfavourable results and abandon mistaken views (Jevons). "Observation and experiment must therefore be carefully con-

ducted and the results accurately recorded for confirmation and future reference. For this purpose scientific apparatus as well as a complete system of terms are necessary—the former for producing and observing phenomena and the latter for accurately recording them in language."

7. **Observation and Experiment as passive and active experience.** It has been remarked by some writers that observation is passive experience while experiment is active experience. This very idea underlies the statement that in observation we are the slaves of nature and in experiment we are the masters of nature. But nothing is wholly active and nothing is wolly passive in this world. In perception we have to attend to the thing perceived and withdraw our attention from all other things that are presented to us. This attention is an active process. The thing attended to must be isolated from all other objects along with which it occurs. This isolation also is an active process. Besides attention and isolation we require also the interpretation of the sense presentations and in order to make it possible we must bring out from within our mind the accumulated ideas and knowledge which we have already gathered in the course of our life. This interpretation is also an active process. In observation besides these active processes we have to regulate our perception with the help of a hypothesis, and to exclude all irrelevant phenomena from our enquiry. Selective element is predominently present in observation. Hence it is wrong to say that

observation is wholly passive experience. Scientific observation is, like experiment, planned, disigned, and deliberate.

In experiment also we are not wholly active, because our activities are much circumscribed by the limitations of our control over nature and natural objects, and the defect of our apparatus, and our failure to eliminate unnecessary or irrelevant factors, e. g., friction, gravity, dust, air cannot be completely eliminated For the materials on which we perform an experiment we depend greatly on nature, e. g. , we require rats, rabbits, frogs etc. , to carry on our experiments. In experiment also it is nature which produces the phenomenon in question, we simply arrange the circumstances in a favourable way so as to induce nature to work in such a manner that we may study its operation in a convenient manner. The various disasters that have happened in making experiments also show how greatly we depend on nature in experiment and the extent of our mastery over nature in experiment. Hence we conclude that it is entirely wrong to say that experiment is wholly an active process. But it should be admitted that active elements are predominant in experiment while passive elements are predominant in observation.

8. **Fallacies of Observation and Experiment.** In making an observation or performing an experiment our duty is to observe all the relevant circumstances and to record them accurately. Therefore we commit the fallacy of **imperfect**

observation if we take into consideration any irrelevant phenomenon or omit to notice some relevant phenomenon or if we observe a phenomenon in a distorted fashion. Our observation remains also imperfect if we fail to keep a clear and accurate record of our observation for future reference and confirmation. Thus imperfect observation and experiment are of various kinds, viz.,

(1) **The Fallacy of Non-Observation.** When a relevant phenomenon is not observed we commit the fallacy of non-observation. If the phenomenon **x** be actually produced by **ABCD** and if we view **ABC** alone as the cause of **x** we shall commit the fallacy of non-observation with respect to **D**. When we cut the string of the punkah it falls to the ground. Now if we view the cutting of the string as the cause of the falling of the punkah then we shall commit the fallacy of non-observation, bacause gravity which is one of the conditions of the falling of the punkah is not observed and is not treated as a part of the cause. Similarly if we purchase a patent medicine on the strength of advertisement and the testimonials granted by a large number of persons we shall commit the fallacy of non-observation for we do not take into consideration those cases in which the medicine was a failure. All faith in dreams, astrology, palmistry, amulets and *mantras* involves the fallacy of non-observation because in such cases we remember only those instances in which the thing in question happens to be true, and do not take into consideration those

vast number of cases in which it fails. We shall see later on that almost all the fallacies of *non-causa pro causa* rest on the fallacy of non-observation. Whenever we find that the supposed cause and effect are disproportionate or inadequate in relation to each other or when we find that the supposed effect is capable of producing the cause there is undoubtedly the fallacy of non-observation in our investigation. This fallacy also underlies the doctrine of the plurality of the causes. We shall see later on that all the experimental methods are baffled by hidden agents unnoticed by us. This non-observation of the hidden agents is the fallacy of non-observation. So the most dangerous fallacy of induction is the fallacy of non-observation.

(2) **The Fallacy of Mal-Observation.** When a relevant phenomenon is viewed in a distorted fashion we are said to commit the fallacy of mal-observation. This fallacy is also committed when a vast sheet of water is observed while travelling in a desert where, as a matter of fact, there is only an expanse of sand and not a drop of water. Similarly we commit this fallacy if we observe ghost at night-time in the places where there are only bushes or white sheets of cloth.

The fallacy of mal-observation is of two kinds, viz., **Illusion** and **Hallucination**. When an actually existing object is viewed in a distorted fashion we have illusion. This happens when we experience a mirage or a ghost or see our brother's face in a crowd when there is only a person resembling the

brother. Thus in an illusion there is an objective basis. In some cases we project our ideas and view the content of our idea as existing outside of us. Such an observation is said to be hallucination. If we experience a load on our head when there is no such load we are said to suffer from hallucination. Those who are mad often see kites, thrones, snakes, etc., when there is nothing in their presence. Hence their observations are generally hallucinations.

The fallacy of mal observation involves the fallacy of non-observation because when we view a rope to be a snake we fail to observe the rope and its qualities. Similarly when a piece of cloth hanging in moon light is viewed to be a ghost then the fallacy of non-observation is committed with respect to the piece of cloth.

The fallacy of non-observation also involves the fallacy of mal-observation. When some of the relevant factors are not observed then naturally the remaining factors that are observed are treated as the entire cause of the phenomenon under investigation. In the symbolical example treated above **A B C** are treated as the total cause of **x** though as a matter of fact **A B C D** constitute the total cause of **x**. Here a part of the cause is viewed as the entire cause and so the real cause is viewed in a distorted fashion and mal-observation is committed.

Both mal-observation and non-observation are equally harmful for inductive investigation. Non-

observation makes us take an erroneous hypothesis to be a valid one while mal-observation makes us treat an irrelevant or imaginary phenomenon as the cause of the phenomenon under investigation. Hence it is not proper to minimise the importance of non observation as a negative error and to place greater importance on mal-observation by describing it as a case of positive error.. It will be more correct to say that non-observation, as has been pointed out already, is more harmful than mal-observation.

It is very difficult to get rid of these fallacies as these depend on the mentality of the persons making the observation and performing the experiment. These are also associated with the instinct of self-preservation and self-propagation. To avoid these we should increase our amount of carefulness and alertness and should repeat our observation and experiment by varying the circumstances in all possible manner and by removing our prejudices and pre-conceived opinions.

The fallacies of observation are also the fallacies ef experiment. There is no special fallacy of experiment These are also the **fallacies of analysis.** Imperfect analysis of phenomena generally give rise to the fallacies of non-observation and mal-observation

9. Exercises.

1. Define Observation and Experiment, giving examples of each ; and explain why these processes require treatment in Inductive Logic. What are the advantages of the latter over the former ? What sciences depend mainly on Observation, and why ? What sciences depend mainly on Experiment, and why ?

2. What is Experiment ? Why is it thought necessary to deal with it in Logic ?

3. Induction derives its premises from Observation and Experiment : Describe and exemplify these two processes showing clearly the difference between them. In what does the superiority of Experiment as a source of premise consist ?

4. Distinguish between Observation and Experiment. Point out the advantages of the latter over the former. Has the former any advantage over the latter ? Fully discuss this question.

5. What are the material grounds of Induction ? Why are they so called ?

6. Distinguish between Perception and Observation. Explain experimental observation. How would you distinguish between popular observation and scientific observation ?

7 What is the importance of Observation and Experiment in inductive inquiry ? Do they alone justify an inductive generalisation ? Illustrate the fallacies which arise from their wrong use.

8. Discuss the comparative advantages of Observation and Experiment, and explain their nature.

9. 'I see my brother' ; how far is this affirmation based on observation and how far on inference ? Show by examples how far experiments help to prove causation ?

10. Observation and Experiment do not differ in degree. Explain this remark.

11. 'A perfect experiment establishes a law' Explain it with examples.

12. What is a fact ? In what sense are facts the foundations of science ?

13. Explain why Experiment is always preferable to Observation.

14 What methods should we follow in getting accurate results in Observation and Experiment ?

15. What are the difficulties of Observation and Experiment ?

16. What are the fallacies of Observation ? How should we get rid of them ?

17. Discuss 'Observation is passive experience and Experiment is active experience'.

18. Explain Natural Experiment. Does the use of scientific apparatus convert an observation into experiment ?

19. Show how experiment can be carried on in education and in geographical investigation ?

20. Explain the various fallacies of analysis.

21. Explain the various forms of imperfect observation.

CHAPTER VI

HYPOTHESIS.

1. Definition of Hypothesis—its implication : Hypothesis is any supposition which we make in order to explain some fact or phenomenon or to establish a causal relation or a law of nature. As for instance, if on my return home from college I find my knife missing, and I make the supposition that my little sister has taken it away, then this supposition will be a hypothesis as it wants to explain the loss of knife. This supposition may be true or false, and so we are to see whether this supposition is supported by facts. It is accepted as true only when it is found to be in harmony with all the known facts, as for example, if I find a fresh-cut wound in the finger of my little sister, and if on the discovery of the knife I find blood marks on it then I accept the hypothesis and believe that my little sister had really removed my knife. Similarly if typhoid breaks out in a town, and if we find by observation that all the persons attacked by this disease are in the habit of chewing the bazar-*pan* then we may make the hypothesis that this *pan* is the cause of the typhoid. But this hypothosis may be true or false, so in order to prove it we must examine the betel used by these men under

a microscope. If we find typhoid germs in these betel leaves then we shall accept the hypothesis as true.

Mill has defined hypothesis as "any supposition which we make (either without actual evidence or on evidence avowedly insufficient) in order to endeavour to deduce from it conclusions in accordance with facts which are known to be real; under the idea that if the conclusions to which the hypothesis leads are known truths, the hypothesis itself either must be, or at least is likely to be true." This definition involves the following factors :—

(i) A hypothesis is a supposition or a guess.

(ii) It has some purpose or end in view, i.e., by means of this hypothesis we try to explain some fact or phenomenon, and to establish some causal relation or law of nature. But this purpose has not been fully expressed by Mill's definition.

(iii) A hypothesis is based either on no evidence or on insufficient evidence. It may also be based on sufficient evidence.

(iv) If the conclusions drawn from the hypothesis be in harmony with the facts then it should be accepted as true.

(v) When we frame a hypothesis we expect that it will explain all the facts and phenomena under investigation But whether it will actually explain them is a matter of future investigation, Therefore at the initial stage a great deal of uncertainty looms large over our hypothesis.

2. **Legitimate Hypothesis.** Though hypo-

thesis is a supposition or guess yet any and every supposition is not a hypothesis. A supposition which is self-contradictory cannot be called a hypothesis. Similarly a supposition of unreal, fictitious thing cannot be a hypothesis, because in Induction we are concerned with facts and phenomena occurring in nature, and so our hypothesis must have a reference to real agents. Our intention in framing a hypothesis is to prove later on by deducing conclusions from it in harmony with the facts which are known to be real. So our hypothesis must not be ambiguous or vague, because from such a supposition nothing can be inferred. Now, when a supposition is free from self-contradiction and ambiguity and when it does not involve any fictitious or unreal agent then and then only the supposition can be rightly called a hypothesis. Such a hypothesis is also called by the name **Legitimate Hypothesis.** Thus we conclude that though every hypothesis is a supposition yet every supposition is not a hypothesis.

Some logicians have used the expression, legitimate hypothesis, for those hypotheses which have been proved to be true. According to them, therefore, a valid hypothesis is a legitimate hypothesis. But it is not correct to identify a legitimate hypothesis with a valid hypothesis A hypothesis is said to be valid when it is found to be true, and is verified to our complete satisfaction and more correctly when it is established by the Method of Difference. But a hypothesis is said to be legitimate when it

satisfies three conditions, viz., (i) when it is free from self contradiction, (ii) when it is free from ambiguity. and (iii) when it is not based on double supposition, i. e., when it does not contain any fictitious element. A hypothesis of such a nature admits of examination and verification. Therefore it is verifiable. But when examined we may find it to be incorrect later on. Thus an invalid hypothesis may be legitimate. We know that the Ptolemaic theory according to which it was believed that the sun moves round the earth is invalid, but no body can question the legitimacy of this hypothesis. We should remember that even a wrong hypothesis is often retained in order to describe the operation of a thing figuratively. Even now we use nerve-fluid and electric current though we know definitely that there is no fluid inside our nerves and there is no current in electricity.

3. **Kinds of Hypothesis.** There are three principal kinds of hypothesis, viz.

(i) Our hypothesis may be a supposition of a cause or of an agent which is assumed to explain a fact or phenomenon, e. g., mosquito is supposed to explain malaria, ether is supposed to explain light, and Neptune was supposed to explain the disturbance in the movements of the planet, Uranus. Such a hypothesis is verified by observation and sometimes by experiment.

(ii) Our hypothesis may be a collocation or combination of several agents, causes or circumstances which are assumed to explain a fact or phenomenon,

e. g., loss in business is explained by the collocation of the following circumstances :—(a) rise in the exchange, (b) the prospect of a European war, (c) the Japanese rivalry and cheap production, (d) absence of proper supervision, (e) misappropriation by the servants, (f) the strike of the working men, etc. Similarly the contact of a spark with gunpowder is supposed to explain an explosion. Similarly the collocation of the heavenly bodies is supposed to explain the movement of the earth round the sun.

(iii) Our hypothesis may be a supposition about a law or mode of operation of an agent or cause or it may be a supposition of an agent together with its law or mode of operation, e. g., the undulation or the mode of vibration of ether is supposed to explain light. The law of gravitation was supposed by Newton to explain the movement of the planets. Such a hypothesis is proved by deduction supported by observation.

Ordinarily or popularly we separate hypothesis of agents, collocation and laws, but scientifically speaking such a hypothesis can hardly explain a fact or phenomenon, because the facts which we come across in our life are very complex in nature, and can be explained only by supposing a number of agents and their collocation or co-operation together with their laws of operation. Thus a scientific hypothesis rests on agents, collocation and laws simultaneously and not separately. In order to explain a case of murder we are to suppose not only

a person but also a motive for commiting the crime. We must also suppose the weapon with which the murder was committed and the circumstances which made the commission of the crime possible, as well as the way the murder was committed. Thus our hypothesis contains within itself agents, collocation and laws simultaneously. Similarly the defeat of the Abyssinians in the last Italy-Abyssinian war is explained by the supposition of many agents, collocation of circumstances, and the mode of operation of the army. Again the Bihar flood is explained by the heavy rainfall on this side of the Himalayas resulting in the flood of the rivers falling into the Ganges and also a heavy rainfall in the Vindhyas resulting in the flood of the river, Son, and the rush of the flood water through the Ganges which flows through Bihar. In this way it can be shown that in every case a hypothesis contains agents, collocation and laws. When any one of these is independently viewed as the cause of a phenomenon we generally identify a part of the cause as the total cause and thereby commit the fallacy of *non causi pro causa.* In such cases we also find that there is a disproportion between the cause and its effect.

Along with these three pricipal kinds of hypothesis the following ones are also considered in Logic :—

(1) The **working, provisional,** and **tentative hypothesis** :— When in explaining a phenomenon under investigation we fail to get at the legitimate

or explanatory hypothesis we form a rough hypothesis for the time being with a view to open out a line of enquiry, and to make us acquainted with the facts or phenomena under investigation. Such a hypothesis is said to be a working hypothesis when we carry on our investigation in its light, i.e., when with the help of this hypothesis we regulate our further enquiry. When a theft occurs in a village the police-officer first of all makes a hypothesis of this kind and conducts the enquiry on the supposition that a certain person committed the theft.

A hypothesis is said to be provisional when we assume it for the time being in order to open out a line of investigation knowing fully well that it will be rejected later on when a better hypothesis will be available. A hypothesis is said to be tentative when a good hypothesis is not available, and so a bad one is accepted knowing fully well that it is not satisfactory. Thus there is hardly any difference between a provisional and tentative hypothesis or between a provisional and a working hypothesis. But these are not useless though they fail to explain the phenomenon under investigation, and though they are subject to drastic revision, modification and even rejection. These are valuable because they open out a line of enquiry and help us in discovering the right hypothesis. Such a hypothesis also helps us in bringing to light some hitherto unknown facts, laws, and phenomena which otherwise would have remained unknown to ourselves. From this point of view every sort of hypothesis,

old or new, valid or invalid has got its merit. So it is often said that any hypothesis is better than no hypothesis. A working hypothesis though rejected, often serves the purpose of describing figuratively the matter of which it was a hypothesis. Even now electricity is described as a fluid though no body maintains now that it is actually a fluid.

(2) **Descriptive hypothesis.** A hypothesis is said to be descriptive when it gives us the ways in which the phenomenon under investigation behaves. In other words the hypothesis of a law as to the operation of the phenomenon under investigation is said to be a descriptive hypothesis. Whereas a hypothesis is said to be *explanatory* when it is a supposition of the cause of the phenomenon under investigation. Such a hypothesis is also called a constructive hypothesis. But any and every hypothesis of law cannot be called descriptive, because this law may be a law of the agents producing the phenomenon is question or it may be a law of the mode of operation of the phenomenon under investigation. When the hypothesis of a law is of the first kind it should be called an explanatory hypothesis. But the hypothesis of law of the second kind is said to be a descriptive hypothesis. If in explaining the deafness of tom-cats with blue eyes we make the supposition that all tom-cats with blue eyes are deaf then our hypothesis will be a descriptive hypothesis. If in explaining the absence of odour in a scarlet flower we make the supposition that all scarlet flowers

are odourless then our hypothesis will be descriptive in nature. Thus a descriptive hypothesis gives us the *how* of a thing but does not give its *why*.

(3) **Representative Fiction.** A hypothesis which contains within it fictitious elements is said to be a representative fiction. But we know that according to the conditions of a legitimate hypothesis we are not entitled to make any double supposition in making a hypothesis. In other words a logical hypothesis must contain only real agents or *vera causa*. By real agents or *vera causa* we mean those facts and phenomena which actually occur in the world and also those which can be reasonably believed to exist in this world. If by *vera causa* we mean only those agents which are known to us and if we are required to make hypothesis with these agents only then the door of all discovery will be for ever closed to us. Hence *vera causa* includes those imaginary agents which can be reasonably believed to exist and deductions from which are found to be in harmony with facts. When a hypothesis contains *vera causa* of this type it is said to be a representative fiction. But very strict strict proof is necessary in order to establish a hypothesis of this kind. The atomic theory, the hypothesis that heat is a form of motion, the supposition of ether, and the undulatory theory of light are all representative fictions. Thus a representative fiction is generally necessary for describing the minute structure and operation of bodies which can never be observed or proved by direct means, i.e.,

by means of our sense organs. "Their utility lies in their suitability to express or describe figuratively the phenomenon in question. By such a hypothesis we render intelligible many obscure phenomena which would have otherwise remained unintelligible." Representative fictions are also called Illustrative hypotheses.

(4) **Verifiable and Verified Hypothesis.** A hypothesis is said to be verifiable when we can deduce conclusions from it, and can compare them with the facts and phenomena occurring in nature. Now this is possible when the hypothesis is free from ambiguity and self-contradiction and does not contain any fictitious element. But on examination a verifiable hypothesis may be rejected or modified. Thus a false hypothesis may also be a verifiable hypothesis. Hypotheses which are ambiguous and which involve double suppositions or fictitious elements cannot be put to the test as no deductions can be drawn from them. There are certain hypotheses which are claimed to be true even when the facts go against them, e.g., it is often supposed by uncultured people that an amulet fails to cure a malady because some body cast his evil eye on it, or because the person wearing it did not live a life of purity. Such a hypothesis is not a verifiable hypothesis and should be rejected at the time of its inception.

A hypothesis is said to be verified when it is established either by the Method of Difference or by the Joint Method, and the conclusions deduced from it are found to be in perfect agreement with the

facts and phenomena occurring in nature. Such a hypothesis also satisfies all the conditions of a good hypothesis. So a verified hypothesis is a true hypothesis about which we cannot entertain any reasonable doubt. In other words it is identical with induction proper.

4. **Conditions of a Hypothesis.** We have seen that the hypothesis is a guess or supposition, but any and every supposition is not a hypothesis A supposition in order to be a hypothesis must satisfy at least three conditions, viz., (1) it must be **definite**, i.e., it must not be ambiguous because ambiguous things cannot be verified

(2) A hypothesis must be **free from self-contradiction** because self-contradictory things cannot be either formally or materially true.

(3) A hypothesis must have reference to real agents or **vera causa** because unreal or fictitious things cannot be verified.

Over and above these bare necessary requir ements a hypothesis in order to be good must satisfy the following conditions :-

(1) It must be **adequate**, i. e., it must explain all the facts and phenomena under investigation so far as they are known to us. If a hypothesis explains some of the known facts but fails to explain some other relevant facts then it will be treated as inadequate. Inadequate hypotheses should either be modified or rejected.

(2) Our hypothesis in order to be good must not contain any unnecessary element in it. In

other words it must not violate the law of parsimony or economy. If we can explain a phenomenon by supposing only one agent then we should not suppose more than that agent. If the creation and maintenance of this world can be explained by the supposition of a single God then we should violate the law of parsimony if in explaining this problem we suppose a plurality of gods or a god and a satan. Similarly if we can explain all the items of-knowledge by experience then we shall violate the law of parsimony if over and above experience we suppose intuition and testimony. Again if a case of theft can be adequately explained by the supposition of a single person then we shall violate the law of parsimony if we soppose a plurality of persons for explaining that case of theft. The hypothesis which contains unnecessary elements is called **Gratuitous hypothesis.** Fowler says that "by this is meant the assumption of an unknown cause, when the phenomenon is capable of being explained by the operation of known causes or the introduction of an extraneous (though it may be known) cause, when the phenomenon is capable of being accounted for by the causes already known to be in operation."

(3) **Our hypothesis must not contradict any law of nature,** i.e., it must fit in or be in harmony with the system of knowledge which we have within our mind. This rule follows from the law of non-contradiction which tells us that two contradictory things cannot be simultaneously true. But in some cases contradictory hypotheses were formed and

later on established, and the laws of nature which were believed to be true were rejected. Originally it was believed that the sun moves round the earth, but Galelio formed the contradictory hypothesis that it is the earth which moves round the sun. The theory of evolution was also a hypothesis of this kind as it contradicts the established notion of creation. But such hypotheses are exceptional in nature and require very strict proof. Ordinarily we are not entitled to contradict any established law of nature or our experience.

A hypothesis which satisfies all these conditions are sometimes treated as legitimate.

5. **Verification of Hypothesis.** Verification is an essential part of a hypothesis, as well as of induction for without it no hypothesis can attain any amount of certainty. In every inductive generalisation we require a hypothesis which again must be verified or proved, otherwise there would remain a great deal of doubt as to its truth. Now verification can be effected in three principal ways, viz., (1) by direct observation, (2) by experiment, (3) by deduction., (4) by the consilience of inductions, (5) by a crucial instance or *experimentum crucis* (6) by the accumulation of facts and uncontradicted experience, (7) by the application of the Experimental Methods, and lastly (8) by showing that we can make predictions with the help of our hypothesis. Let us consider these one by one.

(1) **Verification by Observation.** When a hypothesis supposes an agent we generally verify

it by observing this agent in question, e.g., the supposition that the deviation of the planet Uranus from its calculated orbit was due to the influence of some unknown planet was verified by actually discovering the planet with the help of a powerful telescope and thereby the hypothesis was verified. This newly discovered planet became later on known as Neptune. Similarly if we suppose that the stolen watch is in the pocket of a particular man then we can verify it by actully examining his pocket and finding the watch in it. Again if we suppose that a particular water is the cause of cholera then it will be verified by observation if we can detect comma shaped germs in that water with the help of a microscope.

(2) **Verification by means of Experiment.** A hypothesis is sometimes verified by means of experiment. This is undoubtedly the surest method of verifying our hypothesis. If in explaining a phenomenon we suppose a cause then in order to establish this supposition by experiment we should artificially make the agent produce the phenomenon in question. If we suppose that the comma shaped germs produce cholera then we can prove this hypothesis by injecting these germs in the body of an animal and seeing whether this introduction of germs is followed by cholera. Here we are performing an experiment with the germs and if the animal actually gets cholera then the hypothesis is true and is verified. If we suppose that **A** and **B** together produce **p** then we can verify

this supposition by actually combining **A** and **B** and thereby showing that out of this combination **P** is brought into existence. It is supposed that milled rice is the cause of beriberi. We can verify this hypothisis by keeping rats only on milled rice and observing whether these rats contract this disease or not. But when the phenomenon is beyond our control, e. g., sun spots, or too dengerous e. g, a new legislation, experiment is not possible. In such cases verification by deduction should be resorted too.

(3) **Verification by deduction.** Hypothesis is generally proved by deduction. This deduction can be carried on in two ways, viz., (a) we can deduce the hypothesis in question srom fome already established law, or (b) we can verify this hypothesis by deducing conclusions from it, and showing by means of observation that these conclusions are in harmony with the facts and phenomena occurring in nature. This second kind of verification combines within it both deduction and observation. The supposition that the rusting of iron is due to its exposure to moisture is proved by deducing it from the higher law of oxidation. Empirical laws which are all hypothesis at the beginning are generally proved by deduction. Verification by deduction is sometimes called **indirect verification.** The supposition that the eastern wind is harmful to our health is proved by deducing it from the higher law that poisonous gases are injurious to our health.

Some logicians identify the verification of hypothesis with the proof of hypothesis. There is hardly any reason for drawing a distinction between proof and verification. Ordinarily these three methods of verification are recognised. But we may add to these the following additional methods which are included within the proof of hypothesis. As a matter of fact we should always try our best to verify or prove our hypothesis by all these methods.

(4) **Verification by the Consilience of Inductions.** We can verify our hypothesis by showing that it is supported by other inductions, i.e., by showing that there is conformity or agreement between our hypothosis and the already established inductions we can come to the conclusion that our hypothesis is true. This form of verification involves deduction as in it we indirectly deduce our hypothesis from the already established inductions. Whewell regards consilience of inductions as the most outstanding mark of the truth of hypothesis. If by our hypothesis we can explain the facts and phenomena occurring in a department of nature other than that for which the hypothesis was originally formed then it is likely to be true. Such cases are treated by him as the consilience of Inductions. The law of gravitation was originally supposed to explain the falling bodies on earth. There was consilience of inductions when by it, the orbits of the planets and the moon, and the tides were explained.

But even when a hypothesis is found to be in

harmony with other inductions, we cannot be sure of the validity of our hypothesis. An agreement of this nature simply shows that there is a possibility of our hypothesis being true. Hence the consilience of inductions creates favourable circumstances for the adoptation of a hypothesis but it cannot be treated as the proof of a hypothesis Such a consilience simply shows that the hyphothesis is grounded on uncontradicted evidence.

(5) **Verification with the help of the crucial instance and the experimentum crucis.** This is the best and the most effective way of proving most of our hypothesis. But this involves both observation and experiment. Generally for explaining a phenomenon a number of hypotheses is possible. Now in order to decide between these hypotheses we are required to find out some relevant phenomenon or some instance of the phenomenon under investigation which can be explained by only one hypothesis and not by any other. Now the hypothesis which explains it is accepted to be true while those hypotheses which fail to explain it are rejected as false. Such an instance is called a **crucial instance** when it is found out by observation, and it is said to be **experimentum crucis** when it is found out by experiment. It is absolutely necessary to take the help of either a **crucial instance** or an **experimentum crucis** in order to decide between the claims of rival hypotheses. If we find cases of malaria in a very dry climate then these cases exclude the hypothesis that moist

climate is the cause of malaria and supports the hypothesis that a kind of mosquito is the cause of malaria provided such mosquitos are found in that dry place and in the neighbourhood of these cases. Similarly the aberration of light causing the displacement of the fixed stars cannot be explained by the Ptolemaic theory but it can be explained by the Copernican theory. Therefore this crucial instance decided between the two rival hypotheses.

(6) **Verification by the accumulation of facts and by uncontradicted experience.** If we can show that a large number of facts have been explained by our hypothesis and that we have not come across any phenomenon which contradicts our hypothesis then it should be accepted as true. This is the case with the atomic theory by which a large number of facts have been explained and as yet no inconsistent chemical or other phenomena have been discovered. So it has been accepted as true. But to prove a hypothesis by this method requires much time, and even when the hypothesis explains a large number of cases it is liable to rejection. The suppositions that all crows are black and all swans are white have been rejected though they explained a large number of instances in the past and even now they are supported by a large number of cases. It should be remembered that the validity of a hypothesis cannot rest on the number of cases explained by it. The absence of the cases explained by the

hypothesis or the paucity of these cases is really suspicious, but the number of cases explained by a hypothesis creates simply a favourable impression about the hypothesis but this number alone cannot prove it. This method of proving a hypothesis by the number of cases explained by it may be described as the **method of illustration.**

(7) **Verification by the application of the Experimental Methods** The logical and the scientific or the ideal method of proving or verifying a hypothesis consists in justifying our hypothesis by applying the Experimental methods. In order to prove our hypothesis logically we should apply the experimental methods. If possible we should try our best to establish our hypothesis by means of the most reliable method namely the Method of Difference. If this be not possible we must apply the Joint Method. In no case we should rely simply on the application of the Method of Agreement for this method establishes only probable truth. We should also apply the Method of Concomitant Variations in order to make the supposed cause or law quantitatively precise, and to show the transference of energy from the supposed cause to the phenomenon under investigation.

(8) **Verification by means of prediction.** We are said to verify or prove a hypothesis when we are able to make prediction with the help of our hypothesis. But this method of proof is very shaky in nature. With the the help of the Ptolemaic theory the solar and the lunar eclipses can

be predicted accurately, yet this theory has been rejected in favour of the Copernican theory. Similarly the tides can be predicted with the help of the Ptolemaic theory. Hence this method of proving a hypothesis is popular and spectacular but not logical.

Thus verification, of hypotheses rests on observation experiment. and deduction which underlie all the methods of proof and verification mentioned above. The proof of a hypothesis really consists in showing that it is grounded on the law of causation. and this can be done only by applying the Experimental Methods. But in many cases these methods cannot be applied and a causal relation cannot be established. In such cases the other methods are relied on. But these methods only increase the probability of the hypothesis in question but do not logically prove it. It should be remembered that the logical proof is an ideal proof which can hardly be realised in our practical investigation. Hence there is more scope for the application of the popular methods which are included within the methods of proving a hypothesis.

Carveth Read has given the following canons for proving or disproving a hypothesis :—

(1) "If a new agent be proposed, it is desirable that we should be able to observe it, or at least to obtain some evidence of its existence of a differ-ent kind from the very facts it has been invented to explain."

(2) "Whether the hypothetical agent be per-

ceptible or not, it cannot be extablished as a cause nor can a supposed law of such an agent be accepted as sufficient to the given enquiry, unless it is adequate to account for the effects which it is called upon to explain, at least so far as it pretends to explain them."

(3) "Granting that the hypothetical cause is real and adequate, the investigation is not complete. Agreement with the facts is a very persuasive circumstance, the more so the more extensive the agreement, especially if no exceptions are known. Still, if this is all that can be said in favour of an hypothesis, it amounts to proof by the method of Agreement only ; it does not exclude the possiblity of vicarious causes ; and if the hypothesis proposes a new agent that cannot be directly observed, an equally plausible hypothesis about another imagined agent may perhaps be invented."

(4) "An hypothesis must agree with the rest of the law of Nature; and, if not itself of the highest generality, must be derivable from primary laws."

Carveth Read has summarised his view by saying : "An hypothesis must, to deserve the name in science, be verifiable and therefore definite ; and to establish itself as a true theory, it must present some symptom of reality, and be adequate and unconditional and in harmony with the system of experience." All these are contained in the different forms of verification we have considered already.

6. **The Stages of Hypothesis.** A hypothesis

passes through various degree of certainty or probability from its inception up to the time of its acceptance as a scientific truth. At the time of its formation it can hardly claim any probability. It is then called simply a **provisional hypothesis**. Its main business then is to introduce us to the subject matter of our inquiry. But when we apply this hypothesis to the practical work of investigation and try to solve some problem, fact or law with it then it is called a **working hypothesis**. The function of a working hypothesis is to open out a line of enquiry and to make observation in the light of this hypothesis. If it attains a still higher degree of probability and if we find that by it we can explain a number of facts and we are satisfied that it fulfils the necessary conditions of hypothesis then it becomes a **legitimate hypothesis**. At this stage the test of the scientific canons or Methods is applied to it. "If it is esta blished by the method of Agreement it still remains only probable. If it is further confirmed by the Joint Method it becomes more probable. The Method of Concomitant Variations may further increase its probability but until it is proved by the Method of Difference it does not attain certainty and does not become an inductive truth. When thus proved an hypothesis may be called valid or true. It then becomes equivalent to Induction (Dr. P.K. Ray's Induction).

But when there is any intermixture of phenomena the methods can hardly be applied to test

the hypothesis which tries to explain such an intermixture, for it is only when an analysis of the phenomenon under investigation is possible the methods are applicable. Therefore it is not possible for us to prove a hypothesis by the methods always. Besides we should notice that a hypothesis can be proved by deducing from some already established inductions. When so proved it becomes a **derivative** or **secondary law of nature.** Thus we see that from an insignificant amount of probability a hypothesis may rise up to the certainty of a derivative law of nature.

7. **Theory, Law and Fact.** These are also the stages of hypothesis. We know that at the time when a hypothesis is formed its probability is very insignificant. It has at this moment a vast amount of expectation. But with the progress of investigation, and with the increase of the number of particular instances explained by the hypothesis its probability goes on increasing. Thus when we are able to explain a good many cases by our hypothesis our doubt as to its validity vanishes to a considerable extent, and we believe that its truth is almost well established. At this stage our hypothesis is called a **theory.** Thus we see that a theory is a hypothesis having its certainty established to our satisfaction to a great extent. The word theory is often used in a different sense. In this sense it means a system of laws, truths or suppositions, i.e., hypotheses, governing a particular department of enquiry, e.g., the

theory of light and heat, the atomic theory, etc. Thus we find that in this sense it combines within it more than one law, truth or hypothesis.

If we proceed further in our investigation our doubt as to the validity of the theory becomes totally removed, i. e., when we are able to prove it by the Method of Difference or by the Joint Method or by deducing it from some already established law, then it is itself called a **law**. Thus law is after all a hypothesis which has been established in such a fashion that no one can reasonably cherish any doubt as to its validity. The law of gravitation, the law of definite proportion, the law of relativity, etc., are all examples of laws which were once hypotheses, while the theory of evolution is regarded as theory because it cannot be satisfactorily proved, and therefore people can reasonably doubt it. In the American monkey case a teacher was convicted for teaching the theory of evolution. This shows that it has not yet been universally acknowledged as true.

When a theory becomes universally accepted and proved beyond doubt, and when even the ordinary man accepts it is true then it is sometimes regarded as a **fact**, e. g., the fact of gravity. Thus a hypothesis is sometimes called a fact when it acquires the certainty and clearness of a fact.

The word 'fact' is not generally used in this sense. Ordinarily an event or phenomenon perceived by means of our sense organs is called a fact. But we know that by means of our sense

organs we can perceive only particular objects present before us, and can never perceive any general truth or law. All facts are certain and undisputable in character. In this sense a fact is widely different from a theory and a hypothesis for they are always arrived at by means of inference or supposition, while a fact is a matter of particular, definite, immediate knowledge. But sometimes when a theory acquires the indisputable certainty of a fact it is called a fact.

The word 'fact' is also used in the sense of *datum* or premise of our inference. We know that a theory is always based on some premises. In relation to the theory the premises are called facts. In this sense the terms 'theory' and 'fact' are relative. We know that the higher theories or laws are derived from lower laws or theories. Thus in relation to the higher theories the lower ones may be called facts. Thus the same theory may be regarded as a fact in relation to higher laws, and may be regarded as theory in relation to lower laws or facts.

8. **The Uses of Hypothesis.** Why do we make hypothesis? The hypothetical method is employed by all in explaining the common events of our daily life. We lose a watch and suppose that it has been stolen. We look at the sky and suppose that there will be a storm. We start a business and suppose that it will be profitable, and we marry with the supposition that we shall be happy.

Human mind is so constituted that it cannot rest a little without explaining the facts and phenomena that we come across in our life and without supposing what the future will be. But all these require the help of hypothesis. In fact hypothesis tells us what to look for in a particular case of enquiry.

We cannot live without thinking about the world and its events and explaining them in a way so that we may adjust ourselves to the present and the future without which life cannot continue. All these require the help of hypothesis. So life and thought become impossible if there be no hypothesis.

Similarly in scientific enquiry hypothesis plays a very important part. The facts and phenomena of science are of so heteropathic complexity that we can hardly apply the experimental methods to them. In all such cases our reasoning is hypothetical in nature. In fact without hypothesis science cannot proceed a single step. In scientific enquiry our aim is explanation and discovery which become impossible or imperfect, random or fruitless if not guided by appropriate hypotheses.

In Metaphysics and Theology our reasoning is mainly hypothetical because the two other kinds of reasoning namely deduction and induction can hardly help us there in any way. There cannot be
1 any law from which God, soul, reality, etc., can be deduced, and by induction we can pass from phenomena to phenomena but not to reality, soul or God. Hence our aim in these sciences is to find out that

hypothesis which will best explain the working of the universe as a whole, and the relation between the different factors of this universe, and which will satisfy the religious and moral necessity of human beings.

The law of gravitation, the undulatory theory of light, the discovery of the planet Neptune, the discovery of America, and the scientific inventions of the modern age all prove the importance of hypothesis. Even in observation and experiment which constitute the backbone of science we take the help of provisional and working hypothesis. It has been pointed out already that observation is methodical perception, and in order to be methodical it must be guided by hypothesis. Experiment is designed observation in artificially created circumstances and as such it becomes impossible without hypothesis.

It has been already pointed out that hypothesis gives us causes, laws of nature and collocation by which we systematise the diverse facts of our experience and establish some mastery over the forces of nature. Thus hypothesis lies at the root of our existence, science, and explanation. By systematising the diverse facts of our experience hypothesis enables us to remember them easily, and utilise them in our future investigation.

Even in Deduction hypothesis plays an important part for deductive arguments are all hypothetical in nature. We know that in deduction the premises are supposed or are presented in the form of hypothesis and our business is to show whether any other

proposition is consistent with these suppositions.

It should be noted also that hypotheses have often been found to be extremely valuable even when they have been found to be erroneous. Wrong hypotheses are retained in order to make us understand difficult complex phenomena, e.g., electric fluid, nerve current, etc. Besides, it is with the help of a hypothesis, valid or invalid, we open out a line of enquiry and a bad hypothesis ultimately helps us in detecting the correct hypothesis. Therefore it may be said that any hypothesis is better than no hypothesis.

Now if these are the uses of hypothesis, why did Newton say *Hypothesis non fingo* (i.e., I do not make any hypothesis) ? Newton did not mean that any and every hypothesis is worthless for we find that he himself (Bacon also) made many hypotheses. Newton protested against hypotheses which are not based on facts or which are the children of imagination only. The suppositions or guesses of spider-like philosophers who try to explain the universe and its events by imagination pure and simple were utterly rejected by Newton and Bacon. "It was against the assumption of hypothesis on little or no evidence and obstinate adherence to them, and the attempt to explain the world *apriori* without much reference to the world that Newton protested when he said *hypothesis non fingo*. The truly scientific or logical thinker has none of the spirit which says : If the facts do not agree with the theory so much the worse for the facts."

There is some justification for saying that all knowledge is hypothetical. In perceptual knowledge we suppose that our sense-organs give us correct informations of the facts and phenomena occurring in nature. Hence perceptual knowledge is hypothetical. In all generalisations we assume that nature is uniform. Hence they are all hypothetical, and consequently deductive reasoning which extends these generalisations to fresh cases becomes hypothetical Mathematical reasoning starts with assumption and deduces conclusions from these assumptions. Hence such a resoning is hypothetical. For these reasons Jevons remarks: "All inference proceeds upon the assumption that new instances will exactly resemble old ones in all material circumstances; but in natural phenomenon this is purely hypothetical, and we may constantly find ourselves in error". We have shown already that this is not the real significance of the Uniformity of Nature, and it does not preclude the total destruction of the world. Carveth Read has rightly pointed out that "it is incongruous to use the term (viz., hypothesis) for our tentative conjectures, and for our most indispensable beliefs. The Universal Postulate is a better term for the principle which, in some form or other, every generalisation takes for granted" (Logic-pp264-65).

9. **The Sources of Hypothesis.** How do we make a hypothesis? Any and every person cannot frame a good hypothesis. It requires the intelligence and insight of a genius to be attracted by

a phenomenon, and to form a hypothesis by reflecting on the peculiarity of the phenomenon. It required the genius of Newton to form the hypothesis of gravitation when he observed an apple fall to the ground. It required the genius of Edison to form the hypothesis that sound can be recorded and reproduced when his hand was pricked by a pin while he has engaged in a conversation with his assistant. Sometimes chance also favours the formation of hypothesis. But ordinarily we gather our hypotheses from the following sources :—

(1) The greatest and the most popular source of hypothssis is **Analogy.** The gold mines and the petroleum mines all over the world were supposed at first by analogy, and were subsequently discovered by actual boring in the light of this supposition or hypothesis.

(2) **Concomitant variations** also constitute one of the fruitful sources of hypothesis. The corresponding variations between brain substance and intelligence have led people to suppose that the latter is determined by the former. Extreme cases of variations are more effective in suggesting a hypothesis. The injurious effect of a particular thing is very easily suggested when it is taken in excess, e.g., tobacco. (3) Scientifically we have to form a hypothesis by observing a large number of the instances of a phenomenon and detecting therein the points of similarity, e.g., the examination of the crows of India leads us to the hypothesis that all crows are black. (4) A careful observation

of a small number of cases followed by accurate analysis helps us in forming a good hypothesis. A police officer, for example, studies a pariticular circumstance carefully and by analysing it makes the hypothesis that a certain person is responsible for the crime. This is pre-eminently the scientific method of forming a hypothesis. (5) The excess or deviation from the expected result in an experiment invariably suggests a good hypothesis. (6) Erroneous simple conversion of A propositions often suggests a good hypothesis, e.g., it was found that diamond is transformed into carbon when heat is applied to it, and so it was supposed that carbon also can be transformed into diamond. Fallacious syllogistic reasoning often suggests a hypothesis. The Method of Agreement even when wrongly applied is one of the greatest sources of hypothesis. All these sources inevitably point out the fact that similarity of the phenomena studied and reflection about the circumstances in the midst of which they occur constitute the ground of the formation of hypothesis.

10. **Hypothesis and Abstraction.** Hypothesis is sometimes used for abstraction. Here by abstraction we mean a process of reasoning by which we draw inferences from some definitions which are ideal in character and devoid of any correspondence with real objects in nature, and maintain that our inference based on these definitions will holdgood with regard to the concrete objects of nature. As for example, we start with the definitions of lines, planes, triangles,

etc, and then deduce conclusions from them, and believe that these conclusions are all true with regard to the concrete surfaces and lines that we find in experience. Here we may notice that in getting at the ideal definitions of points, lines, triangles, etc. we first of all observe a good many instances of real objects and phenomena, and then after analysing them we exclude a great deal of their properties and abstract or separate those that seem to be essential, and ground our definition on them. Hence these definitions are suppositions like hypothesis. Thus in both abstraction and hypothesis the actual is explained by the ideal or supposed things or phenomena. In both of them we expect that the supposed thing represents a truth actually existing in the world. But in hypothesis there is a guess as to the unknown and the future whereas there is no such guess and corresponding risk in abstraction. Deduction from hypothesis must perfectly correspond with reality while there is imperfect correspondence between the deductions from abstraction and actual phenomena. Besides hypothesis views nature in its dynamic aspect while abstraction views nature in its statical aspect. In the hypothesis we are concerned with cases of succession while in abstraction we are more concerned with the relations of coexistence. Hence it is not proper to identify hypothesis with abstraction. About this Carveth Read remarks: "This seems, however, a needless and confusing extension of the term; for an hypothesis

proposes an agent, collocation or law hitherto unknown; whereas abstract reasoning proposes to exclude from consideration a good deal that is well known. There seems no reason why the latter device should not be plainly called an abstraction."

11. **The Method of Limit.** This method is similar to the method of abstraction. The principle on which this method is based may be defined thus: What is true up to the limit is true at the limit. Now by limit we mean the extreme case to which all the actual cases approach without ever being identical with it Now by extending this idea to abstraction we may hold that the abstract represents the extreme cases of individual objects, agents, laws, and phenomena. But the process of reasoning is reversed and it is believed that what will hold good with regard to the abstract will also hold good with regard to the concrete cases.

12 **Baconion Method of Varying the Circumstances.** This has been considered already along with the history of the inductive form of reasoning. This method, as we have seen, consists of the following processes:—

(1) We must take the positive instances of the phenomenon under investigation.

(2) We must take the negative instances of the phenomenon under investigation.

(3) We must take the instances in various degrees and quantities.

(4) We must consider also the instances of

the cross, i.e., the crucial instances in order to eliminate the rival hypotheses and the non-causes.

From these methods Mill later on developed the Experimental Methods.

13. Exercises.

1. Define and illustrate Hypothesis and explain the implications of your definition.
2. State Mill's definition of Hypothesis and explain its implications.
3. Is any and every supposition a Hypothesis? If not, what conditions must a supposition fulfil in order to be a hypothesis?
4. Given a verifiable Hypothesis what constitutes its proof or disfroof?
5 Distinguish between verifiable and verified Hypothesis. How would you verify a given hypothesis?
6. What are the various kinds of Hypothesis? How would you verify each of them?
7. What are the conditions of a legitimate hypothesis?
8. How and why do we make a hypothesis?
9. What are the uses of Hypothesis?
10. Explain the differeut sources of Hypothesis.
11. Explain clearly the following :—Working Hypothesis, Provisional Hypothesis, Tentative Hypothesis, Descriptive Hypothesis, Explanatory Hypothesis, Representative Fiction, Gratuitous Hypothesis.
12. Explain clearly the relation between

Hypothesis and Induction. Can there be any Induction without Hypothesis ?

13. Explain the different forms of the verification of Hypothesis and examine their respective value.

14. Explain and illustrate :—Crucial instance, Experimentum crucis, *Hypotheses non-fingo*, *vera causa* and Theory.

15. Explain the stages through which a hypothesis passes from its inception up to its acceptance as a law.

16. Explain the relation between Hypothesis and Abstraction. What do you understand by the Method of Abstraction and the Method of Limit ?

17. Explain and illustrate the method of Hypothesis.

18. What is meant by Hypothesis in Science ? What different kinds of Hypothesis are there ? Give examples. Explain how Hypotheses contribute to scientific discovery, citing instances. Explain the relation of Hypothesis to Induction.

19. (i) What is Hypothesis ? (ii) What are the characteristics of a legitimate hypothesis ? How does a legitimate hypothesis differ from a scientific induction ? Give illustrations. (iii) What is meant by a working Hypothesis ?

20. What is meant by varying the circumstances in scientific investigation ? What is the use of the process ? Give illustrations to show its use and necessity

21 Suppose that on returning home you find one of the panes of your window broken ; show how you would apply the Method of Hypothesis in this case.

22. Distinguish between a working Hypothesis and an established Hypothesis.

23 Distinguish between a theory and a hypothesis. Give the canons to which a good hypothesis

must conform and illustrate them. Explain the function of hypothesis in induction.

24. What do you understand by varying the circumstances, crucial experiment, theory, and hypothesis ?

25 Do Hypotheses assist Observation in any way ? If so, how ? What are the other uses of hypothesis ? Distinguish between a working hypothesis and a descriptive hypothesis

26. Give examples of (a) Hypothesis about unknown agent (b) Hypothesis about the mode of operation of known agent. (c) invariable hypothesis. Does the verification of deductions from a hypothesis turn it into a certainty ?

27. If there has been a theft in a room, how would you proceed to frame hypotheses (a) as to the identity of the thief, and (b) as to the manner in which the theft was committed ?

28. A man is found lying on a railway track wounded and lifeless. Frame two hypotheses about the causes of his death.

29. Explain the relation between Induction and legitimate hypothesis. When is an hypothesis said to be valid ?

30. It is said that all induction depends upon Hypothesis. How far is it true ?

CHAPTER VII

The Experimental Methods.

1. **Introduction.** We have seen that the aim of Induction is to establish universal real propositions which are in agreement with the facts and phenomena occurring in nature, and on the authority of the law of causation, and the uniformity of nature. Thus in induction we require first of all a relation between two phenomena, and then a generalisation of this relation. Logic advises us to generalise a relation only when it is grounded on the law of causation. Therefore the most fundamental requirement of Induction is the establishment of causal relations. Mill has formulated five methods for the establishment of causal relations, and these methods are called the Experimental Methods or the **Canons of Direct Induction.** These Methods do not embody self-evident truths, and so the question naturally arises how these methods have been arrived at.

2. **Deduction of the Experimental Methods** : The Experimental Methods are five in number, viz., the method of Agreement, the Joint Method, the Method of Difference, the Method of Concomitant Variations, and the Method of Residues. We shall see later on that of these five

methods the Joint Method is a corollary of the Method of Agreement, and the Method of Residues is a corollary of the Method of Difference. Thus there are three fundamental methods, viz., the Method of Agreement, the Method of Difference, and the Method of Concomitant Variations. All these have been developed from the three methods of elimination derived from the scientific view of causation. We have seen already that according to this view the cause is the invariable, unconditional, immediate antecedent of an event which is called its effect, and is quantitatitively equal to it. Here we notice that the cause is an invariable antecedent. From this it follows **that no variable antecedent can be regarded as the cause.** In other words if we can eliminate an antecedent without affecting the phenomenon under consideration then that antecedent cannot be treated as the cause of the phenomenon, or part of its cause. Thus we get the first principle of elimination : *Whatever antecedent can be left out without prejuidce to an event cannot be regarded as the cause or part of the cause.* Suppose a person is suffering from diarrhoea. He supposes that potato is the cause of his diarrhoea, and so he gives it up. But he goes on suffering from the disease as before without any modification, and so it is sure that the eating of potato cannot be regarded as the cause of his diarrhoea. From this principle the Method of Agreement is deduced. This Method tells us that *if two or more positive instances*

The first principle of elimination.

of a phenomenon under investigation have only one other circumstance in common then that circumstance is causally connected with the phenomenon.

The M. of Agreement follows from this principle.

If **ABC** be followed by **pqr**,
ADE be followed by **pst**,
and if **AFG** be followed by **puv**

then according to the Method of Agreement **A** is the cause of **p** or is causally connected with it. Here B, **C**, **D**, **F**, **G**, can be eliminated without prejudice to **p**, and so according to the principle of eilmation they cannot be regarded as the cause of **p** or part of its cause. Therefore the remaining alternative, viz., **A**, should be treated as the cause or part of its cause.

We find from the definition of the scientific cause that the cause is an invarible unconditional antecetent, and the law of causation tells us that there is a bond of necessity connecting the cause with its effect. Hence when the cause occurs the effect must take place, and when the cause disappears the effect also must disappear. Hence from the scienitific view of causation we get the following principle of elimination: *Whatever antecedent cannot be left out without prejudice to the effect, other circumstances remaining the same, must be regarded as the cause or part of its cause.* When light is eliminated from a room we fail to see the objects of that room and so we conclude according to this principle that light is causally connected with the seeing of objects. The Method of Difference

The second principle of elimination.

follows from this principle of elimination, for according to it *if the positive and the negative instance of a phenomenon agree in all respects save one then that one should be treated as causally connected with the phenomenon.* In other words, *if with the introduction of an agent some phenomenon appears, or if with the withdrawal of an agent some thing disappears other circumstances remaining unaltered then that agent must be causally connected with the phenomenon or thing.* This method is symbolically illustrated in the following manner :—

The M. of Difference follows from this principle.

If **ABC** be followed by **pqr**,

and if **BC** be followed by **qr**,

then according to the Method of Difference **A** is the cause of **p** or is an indispensable condition of it.

Here we notice that **A** cannot be eliminated without prejudice to **p**. In other words when **A** is eliminated **p** becomes at once eliminated. Besides **B** and **C** cannot be regarded as the cause of **p** because when they are present in the second instance **p** does not occur. Hence the remaining antecedent **A** must be treated as the cause of **p**. Thus the Method of Difference follows from the scientific view of causation.

The third principle of elimination.

We have also found that according to the scientific view the amount of energy in the cause is equal to and identical with the quantity of energy in the effect. Therefore any quantitative variation in the cause must imply a corresponding quantitative variation in the effect to maintain this equi-

valence. From this it follows that *if two phenomena be found to vary correspondingly in their quantity then they should be treated as causally connected provided the accompanying circumstances remain unaltered.* It also follows that *when two phenomena are related in such a fashion that when one varies the other remains constant then they cannot be treated as causally connected.* The Method of Concomitant Variations is based on these truths. According to this Method *whenever two phenomena are found to vary correspondingly, other circumstances remaining unchanged, then they should be treated as causally connected.* The symbolical illustration of this method is as follows :

The M. of Concomitant Variations follows from this principle.

If **ABC** be followed by **pqr**,

if **2A**, BC be followed by **2p, qr**,

and if **3**A, **BC** be followed by **3p, qr**, then according to this method A should be treated as causally connected with **p**.

Here **B** and **C** cannot be regarded as the cause of **p** because they remain constant when **p** varies quantitatively. Therefore the remaining antecedent must be treated as the cause of **p**, or the variations in **A** are causally connected with the variations in **p**. This shows that the Method of Concomitant Variations follows directly from the third principle of elimination.

Thus we find that the three experimental methods follow directly from the scientific view of causation. Of the remaining methods the Joint Method is a special case of the Method of Agreement, and the

The remaining Methods follow from the first two Methods.

Method of Residues is a corollary of the Method of Difference. Thus all the Experimental Methods follow from the scientific view of causation.

The Experimental Methods are the methods of proof.

3. **The Experimental Methods.** Now we shall consider one by one all the Experimental Methods. These are treated as the **methods of proof**. i.e.. with their help we prove our hypotheses. and thereby transform them into induction. When the conditions laid down by any one of these methods are fully satisfied a causal relation can be established. But these conditions are so very stiff that it is very difficult to satisfy them. These methods require instances either agreeing only in one point or differing only in one point, but the phenomena experienced by us generally agree in more than one point or differ in more than one point. So the ideal laid down by these methods can hardly be satisfied by us. In all the methods with start with a number of hypotheses and then with the help of the instances of the phenomenon under investigation we show that no one of the hypotbeses except one can be accepted as true. and so the remaining hypothesis is accepted as true. The cogency of all these methods rests on the elimination of all rival hypotheses, or the elimination of the non-causes.

The Fundamental principle underlying all the Methods.

(i) The Method of Agreement.

(a) **Definition or canon of the Method of Agreement :**

If two or more (positive) instances of a phenomenon under investigation have only one other

circumstance (antecedent or consequent) in common, that circumstance is the cause or the effect of the phenomenon, or connected with it by causation.

(b) **Symbolical illustration** :

If **ABC** be followed by **pqr**,

If **ADE** be followed by **pst**,

and if **AFG** be followed by **puv**,

then according to the Method of agreement we can conclude that **A** is the cause of **p** or is connected with it by causation.

The cogency of this Method.

Here we have considered three positive instances of **p**. All these instances have only one other circumstance, viz, the antecedent **A**, in common Therefore according to the definition **A** should be treated as causally connected with **p**. The cogency of this method rests on the fact that no one of the antecedents except one can be treated as the cause, because when they are absent the phenomenon under investigation takes place. In the symbolical illustration B, **C**, **D**, **F**, **G**, cannot be treated as the cause of **p** because when they are absent **p** occurs. Hence this Method rests on the principle : Whatever antecedent can be left out without any prejudice to the phenomenon under investigation cannot be treated as the cause or part of the cause.

The principle on which this Method is grounded,

(c) **Concrete illustrations :**

(i) If we apply heat to butter kept in an earthen pot we find that it melts. Similarly if we apply heat to coconut oil kept in a glass bottle, we

find that it melts. Again if we apply heat to vaseline kept in an iron vessel we find that it also melts. Hence we conclude according to the Method of Agreement that the application of heat is the cause of the melting of oily substances.

(ii) In the morning we find that dew is deposited on the blades of grass, on a piece of slate, on iron bars, and on bamboo sticks, and in every case we find that the temperature of the objects on which dew is deposited is less than the temperature of the surrounding atmosphere. Other circumstances being different we conclude that the comparaitve coolness of the surface is causally connected with the formation of dew.

(iii) If we examine Italy, Brazil, Bengal, and Assam we find that all these places agree with regard to the presence of anopheles mosquito though there is difference with regard to many other things. So we conclude according to this method that this kind of mosquito is causally connected with malaria.

(iv) During the last outbreak of cholera in Monghyr it was found that all the persons who contracted the disease were in the habit of chewing the *bazar pan*, though they differed in all other habits. So it was conclued according to this method that the *bazar pan* was causally connected with the epidemic in Monghyr. The conclusion would have been conclusive had the *bazar pan* been examined under a microscope, and the comma shaped germs detected on it.

(d) Criticism of this method.

(1) It is an *observational method* on account of two reasons, viz., (i) in this method the negative instance of the phenomenon is not considered, and (ii) in most of the cases we proceed from a phenomenon to its cause, Besides the conclusion established by this method is only probable on account of the fact that the instances of the phenomenon under investigation are gathered by observation.

It is an observational method.

(2) The scope of this method is greater than the scope of any other method because it is widely used in our every day life, and in connection with matters derived from observation. We generally apply this method to all those cases also which are beyond our control, or are too dangerous to be experimented with. Besides on account of the fact that under this method we do not require any negative instance of the phenomenon under investigation the scope of this method becomes considerably greater than any other method.

This Method has the greatest possible scope.

(3) In this method we generally proceed from the effect to the cause as in the *post mortem* examination. In it we also proceed from the cause to the effect, e. g., when the farmers find that the monsoon fails to break out at the proper time they infer that the harvest will be bad. Similarly teachers conclude that intelligent and diligent students will come out successful because they have found many such students coming out successful.

In this method we generally proceed from the effect to the cause.

(4) The greatest function of this method is to suggest good hypotheses. Our every day knowledge and practical knowledge are generally grounded on this method. This mehod also prepares the way for the application of the Method of Difference, which is therefore grounded on this method.

It suggests good hypotheses.

All these may be said to be the *merits* or advantages of this mehod, and the following may be treated as the disadvantages or *demerits* of this method :-

Demerits :

(5) The geratest demerit of this method lies in the fact that it does not take into consideration any negative instance of the phenomenon under investigation, and consequently it does not show that when the supposed cause is absent, the supposed effect is also absent. In the symbolical illustration mentioned above we do not take any instance in which A or **p** is absent. In other words the method does not show that along with the elimination of the supposed cause the supposed effect becomes eliminated.

It does not consider any negative instance.

(6) The second great demerit of this method lies in the fact that it is completely frustrated by the plurality of causes. In the symbolical illustration the phenomenon **p** might have been produced by **B** in the first case, **D** in the second case. and F in the third case, and A may be an irrelevant circumstance. It is on account of this defect we find that in some cases this method establishes entirely erroneous conclusion, e. g., when rose syrup with castor oil is given to a person he gets loose evacuation. Again if rose syrup with liquid paraffin is given to a person

It is frustrated by the plurality of causes.

Illustrations of bad conclusions.

he also gets loose evacuation. Again if rose syrup with croton oil be given to a third person he will also have loose evacuation. Thus according to this method rose syrup becomes the cause of loose evacuation. But we know it is not the case. Similarly if we find one year that the number of students who pass the I. A examination of the Patna University in the first division have moustache we may conclude according to this method that the possession of the moustache is the cause of success in the first division. But we know there is no causal connection between them.

Three methods for the elimination of the plurality of causes.

Now we may enquire how we can get rid of the plurality of causes in connection with the Method of Agreement. We can remove this defect in three ways, namely, by multiplying the instances, by applying the Joint Method, i. e., by taking the negative instance of the phenomenon under investigation, and by applying the Method of Concomitant Variations. The more the number of instances taken into consideration and the more the variations of the accompanied circumstances, the more is teq value of the conclusion established by this method, and the less the chance of the plurality of causes to frustrate this method. If we take into consideration the negative instance of the phenomenon under investigation, and if we find that along with the elimination of the phenomenon the supposed cause also becomes eliminated, than the probability of the conclusion being true will be very great. The value of the Joint Method rests on the fact that

these negative instances are taken into consideration and thereby the difficulty due to the plurality of causes is removed. Again if we increase or decrease the quantity of the supposed cause, and if we find that the phenomenon under investigation also varies quantitatively, other circumstances remaining unaltered, then we can be sure that the supposed cause is a real cause, and is not frustrated by the plurality of causes.

It requires a great number of instances

(7) Though this method assures us that we can establish a legitimate conclusion from two instances of agreement yet in order to establish a conclusion by this method we are required to consider a vast number of instances though it is based on the nature of the instances. Besides this method generally considers instances gathered from observation. Hence it is not possible for us to know all the antecedent circumstances. In many cases the antecedents are known imperfectly. For this reason the conclusion arrived at by this method is *probable*, and the method itself is treated as the method of discovery, and not a method of proof.

It is a method of discovery only.

It neglects the quantitative aspect of causality.

(8) This method does not try to show the quantitative equivalence between the cause and its effect. Neither does it show the transference of energy from the supposed cause to its effect.

Does it establish causal relation between co-existing phenomena?

(9) According to the definition of this method, as defined by Mill, co-existing phenomena may be viewed as cause and effect, e.g., we find that industrious countries are wealthy though other circumstances are all different. Hence according to

the Method of Agreement industry becomes the cause of wealth. But these are co-existing phenomena, and so they cannot be viewed as cause and effect. But this defect has been removed by inserting the words 'antecedent and consequent' in the definition of this method.

(e) **The Method of Agreement compared with the Simple Enumerative Induction.** In the Simple Enumerative Induction a universal real proposition is arrived at after an examination of a large number of the instances covered by such a proposition. Such a reasoning is grounded on uncontradicted experience, and so it is likely to be shattered by coming across a contrary instance, as has been in the case of 'All swans are white' established by Simple Enumeration. In the Method of Agreement we practically require a large number of instances of the phenomenon under investigation in order to establish a causal relation though the definition of the Method tells us that from two or more instances a conclusion is possible. This method is grounded not on uncontradicted experience but on the law of causation. In this Method it is the *nature* of the positive instances excluding the possibility of the accompanying phenomena being treated as the cause which enables us to establish a causal relation. But the Simple Enumerative Induction rests entirely on the *number* of the favourable instances and the absence of any contrary instance, but not on the nature or character of these instances. In it the possibility

Simple Enumerative Induction rests on the number of instances and not on their nature, while the M. of Agreement rests on the nature of the instances.

of the accompanying phenomena being treated as the cause is not excluded.

The M. of A. tries to establish a causal relation while Simple Enumeration does not make such attempt.

In the Method of Agreement our direct aim is to establish a causal relation, and through it we are allowed to make a generalisation and establish a universal real proposition. But in the Simple Enumerative Induction we never care to establish any causal relation, but in it we directly rush to a universal real proposition. Generally cases of co-existence are considered in the Simple Enumerative Induction, while the Method of Agreement considers only cases of succession This Method as defined by Mill can be applied to cases of co-existence, but this defect has been removed by inserting within the definition of the Method the words 'antecedent and cosequent.'

One of them considers cases of co-existence while the other considers cases of succession.

Both the Method of Agreement and the Simple Enumerative Induction establish probable conclusions, but the degree of probability in favour of the conclusions established by the Method of Agreement is considerably greater than that of the conclusions established by the Simple Enumeration. The conclusions established by Simple Enumeration holds good in the adjacent cases, and their extension to distant or remote cases is always risky. But the conclusions arrived at by the Method of Agreement are universally applicable.

The Method of Agreement is completely frustrated by the plurality of causes, but this question does not arise in connection with the Simple Enumerative Induction as it does not pretend to

establish any causal connection. A reliable conclusion can be arrived at even by the Method of agreement when its requirements are fully satisfied. Besides it is not impossible for us to satisfy these requirements. But a reliable conclusion can never be arrived at by Simple Enumeration and its requirements can never be satisfied because it is impossible for us to examine all the instances and to be sure that there is no contrary instance, and *there will not be any in future.*

Can we establish a reliable conclusion by the M. of A ?

The Simple Enumerative Induction is generally concerned with superficial characteristics while the Method of Agreement is connected with the essential features of things which determine their activities or causation. The Simple Enumerative Induction requires instances like the following :— A_1 is x. A_2 is x, A_3 is x, A_4 is x, etc Here the elimination of the non-causes or rival hypotheses is not considered. But the Method of Agreement requires instances like the following :— ABC followed by pqr. ADE followed by pst, AFG followed by puv. Here the elimination of the non-causes or rival hypotheses is the essential requirement. Hence we conclude that the Method of agreement is radically different from the Simple Enumerative Induction.

The M of A rests on the elimination of the non-causes but this element is neglected by simple enumeration.

(ii) **The Joint Method.**

(a) **Definition.**

If (i) two or more instances in which a phenomenon occurs have only one other circum stance (consequent or antecedent) in common,

while (ii) two or more instances in which it does not occur have nothing else in common, save the absence of that circumstance; tye circumstance in which alone the two sets of instances differ throughout (being present in the first set and absent in the second) is the eflect or the cause of the phenomenon, or causally connected with it.

(b) **Symbolical illustration :**

If **ABC** be followed by **pqr**,

if **ADE** be followed by **pst**,

and if **AFG** be followed by **puv**,

and

if BCM be followed by **qrm**

if **DEN** be followed by **stn**.

and if **FGO** be followed by **uvo**,

then according to the Joint Method we conclude that A is the cause of **p** or is causally connected with it.

This Method rests on the elimination of the non-causes.

Here we have taken two sets of instances. In the first set the phenomenon under investigation, viz., A occurs, while in the second set it does not occur. The first set of instances, i. e , the positive set, has only one other circumstance, viz., the consequent **p**, in common, while the second set of instances, i. e., the negative set, has nothing else in common save the absence of the consequent **p**. Therefore according to the definition of the Joint Method we can establish a causal relation between A and **p**. Now the cogency of the conclusion lies in the fact that no one of the antecedents B, **C**, **D**, E, **F**, G can be treated as the cause of **p** because when

they are present in the negative set **p** is absent. Hence it is reasonable for us to conclude that the remaining antecedent, viz., A, is the cause of **p**. Here we notice also that when A is present **p** is present, and when A is absent **p** is also absent. But along with the elimination of A other changes are introduced. But these cannot be treated as the cause of the phenomenon because when they are present the phenomenon under investigation dose not occur.

Thus this method is grounded on the following principle of elimination :—Whatever antecedent can be eliminated without prejudice to the effect cannot be regarded as the cause of that effect or part of its cause ; or nothing can be regarded as the cause in whose absence the phenomenon under investigation takes place, and in whose presence the phenomenon does not take place. We have seen already that a causal relation implies that when the cause is present the effect must be present and when the cause is absent the effect must be absent. This principle underlies all the experimental methods, and in every one of them the exclusion of the rival hypotheses enables us to establish a causal relation.

Principle underlying this Method.

(c) **Concrete illustration** : (1) One night a number of objects are exposed and we find that dew is deposited on every one of them. We find also that the surface of all these objects are cooler than the surrounding atmosphere and there is no other point of agreement amongst them. Another night

these objects are again exposed but no dew is formed and we find that the surfaces of these objects, this time are not cooler than the surrounding atmosphere. Hence according to the Joint Method we conclude that the comparative coolness of the surface is the cause of the formation of dew.

(2) In the Napoleonic wars it was found that when Napoleon was present with his army the army was victorious but when he was absent from the army the army was defeated though these instances of the presence and absence of Napoleon did not agree in any material point. Hence according to the Joint Method Napoleon's presence was the cause of the victory of the French army.

(3) In all the great wars that were fought in ancient time it is found that the army was victorious when the cavalry was good, and it was defeated when the cavalry was inefficient Hence the efficiency of the cavalry was the cause of victory in war in ancient time.

(d) **Merits and demerits of the Joint Method.** (1) From the definition of the Method it is clear that we can establish a causal connection from two positive and two negative instances, yet as a matter of fact in order to establish a causal connection by this method we require a large number of instances. But it should be remembered that the conclusion is not grounded on the *number* but on the *nature* of the instances. The Joint Method requires a large number of instances in order to be satisfied as to the elimination of all possible rival hypotheses or non-

This Method requires a large number of instances.

causes. But a reasonable conclusion from two or more instances is possible when they fully satisfy the requirements of the method, which is very difficult to do when the instances are gathered by observation.

(2) The greatest merit of this method lies in the fact that the conclusion established by this method is not frustrated by the plurality of causes because the possibility of any one of the circumstances being regarded as the cause is negatived by the negative set of instances in which these accompanying circumstances occur, but the supposed effect does not.

It is not vitiated by the plurality of causes.

(3) When the phenomenon under investigation is not under our control we cannot apply the Method of Difference which is the most reliable method. In such cases we should always try to base our conclusion on the Joint Method.

It is applied when the phenomenon is not under our complete control.

(4) This method gives us a reliable conclusion in practice, but when the instances do not fully satisfy the requirements of this method, then of course we are likely to get unreliable conclusion by it. The instances gathered by means of observation generally agree in more points than one. Hence strictly speaking we can hardly apply this method to observational instances. Yet as a matter of fact we widely apply this method to observational instances, and so this method comes to establish probable conclusions. When the instances are under our control experiment is possible. In such cases we invariably apply the Method of Difference. But if

It gives us a reliable conclusion. By it we establish a defective conclusion when its application is defective.

we apply the Joint Method in such cases then it will also give us undoubtedly a reasonable conclusion. Hence there is no defect in the method itself but the defect arises in the way in which we apply it in practice.

(5) This method fails to prove the unconditionality of the causal relation, i.e., it cannot show that the cause established by this method can independently produce the phenomenon treated as the effect.

(6) This is an observational method as in it we generally proceed from the effect to the cause, and in observation all the antecedents are not known definitely, and it may happen that some of the hidden antecedents may be the real cause of the phenomenon under investigation. e.g., we conclude by the Joint Method that the magician's wand is the cause of the magic because whenever the magician touches an object with it the magic takes place. But when he does not touch it with the wand the magic does not take place. The real cause of magic, we know, is the secret manipulation by the magician or his sleight of hands.

It is frustrated by hidden circumstances.

(7) The negative instances should be exhaustive, i.e., we should take in them all the positive instances of the accompanying phenomena. But in practice this is not done exhaustively. Hence though this method is formally free from the difficulty of the plurality of causes yet practically it is not so.

(8) In order to establish a causal relation we must take into consideration its quantitative aspect,

i.e., we must show that there is a transference of energy from the supposed cause to the supposed effect. Without this transference of energy we cannot be sure of the causal relation. Hence we must apply the Method of Concomitant Variations after applying the Joint Method.

It neglects the quantitative aspect of causality.

(9) In Mill's definition of this method, the words 'antecedent' and 'consequent' do not occur. Hence according to Mill's definition we can establish a causal relation between the co-existing phenomena and thereby commit blunder But in the modern definition on account of the inclusion of the words 'antecedent' and 'consequent' it is not possible to establish a causal relation between co-existing phenomena by this method.

Can we establish a causal relation between co-existing phenomena by this method ?

(iii) **The Method of Difference.**

(a) **Definition.** *If an instance in which a phenomenon occurs and an instance in which it does not occur have every other circumstance in common save one, that one (whether antecedent or consequent) occurring only in the former; the circumstance in which alone the two instances differ is the effect or the cause or an indispensable condition of the phenomenon.*

(b) **Symbolical Illustration.**

If **ABC** be followed by **pqr**,
and if BC be followed by **qr**,
then according to the Method of Difference we conclude that **A** is the cause of **p** or an indispensable condition of it.

Here we have at first taken an instance in

It rests on the elimination of the non-causes.

which **A** occurs, and then an instance in which **A** does not occur. These two instances have every other circumstance in common save and except one, namely the consequent **p** which occurs in the positive instance of **A**. So according to the definition A becomes the cause or an indispensable condition of **p**.

It does not always prove the total cause.

The cogency of the conclusion lies in the fact that no one of the accompanying circumstances, namely B and **C**, can be treated as the cause of **p** because in the second instance when they aro present **p** is absent. Thus we are bound to maintain that the last alternative namely A is the cause of **p**.

This method does not give us always the total cause of a phenomenon. To cover such cases the expression 'indispensable condition of the phenomenon' has been included in the definition. So in applying this method we should try to be sure whether the established cause is the total cause or only a part of the cause. When we view a part of the cause as the total cause we commit the fallacy of non *causa pro causa*, e. g., if we cut the string of a punkah it falls to the ground. So the cutting of the string is the cause of the falling of the punkah according to the Method of Difference But we know that it is really a conditon of the falling of the punkah, the other important condition being the attraction of the earth. i. e., gravition. This example also shows that this method is baffled by hidden circumstances, and is likely to be frustrated by the fallacy of non-observation.

It is frustrated by hidden agents and is likely to be vitiated by fallacies.

(c) **Two ways in which the method can be applied :** It appears from the definition that this method requires two separate instances, but as a matter of fact in practice we require two stages of one and the same phenomenon. For instance in this method we first of all take a phenomenon and introduce in it some agent or circumstance and see what change takes place in the phenomenon immediately after the introduction of the agent or circumstance. This change is the effect of the agent or circumstance introduced. *Here we apply this method by way of addition.*

It may be applied by way of addition.

This methods can be applied by way of subtraction also. We may take away or eliminate an agent from a phenomenon and see what change takes place in the phenomenon or what consequent becomes forthwith eliminated. This eliminated consequent must be the effect of the eliminated agent. *Here this method is applied by way of subtraction.* When the eyes are closed vision becomes at once eliminated. Therefore this method tells us that the eye is the organ of vision. Here the Method of Difference is applied by way of subtraction. When we rub our hands heat is generated, other circumstances remaining unaltered. Therefore according to this method the rubbing of hands is the cause of heat. Here the method is applied by way of addition. Hence it has been said that this method rests on the following principles : "If the addition or subtraction of an agent is followed respeactively by the appearnce or disappearance of an event, and if all other cir-

It may be applied by way of subtraction.

The principle on which this method is grounded.

cumstances remain the same, then that agent is the cause of the event.

It is applied both in experiment and in observation

This method is pre-eminently an experimental method, and it is widely used in experiment. Yet it is also used in our every day life, and by applying it human beings learn at an early state of their lives the various functions of their organs.

(d) **Concrete illustrations.** Take a bottle of coconut oil and apply heat to it. We find that the oil melts immediately after the application of heat. Therefore heat is the cause of the melting of oil. Put an electric bell inside a receiver filled with air, ring the bell and sound is heard. (This is the positive instance of air.) Now pump out the air from the receiver and when there is no air inside the receiver ring the bell again. This time no sound is heard. (This is the negative instance of air.) These two instances have everything in common save the sound in the first case. Hence according to this method air is causally connected with the production of sound.

It is not frustrated by the plurality of causes.

(e) **Merits of this method :—**

(1) In this method we generally proceed from the cause to the effect and so it is not likely to be frustrated by the plurality of causes. Here we consider a negative instance of the phenomenon under investigation and this negative instance shows conclusively that no one of the accompanying circumstances can be treated as the cause of the supposed effect. Hence the conclusion arrived at by this method is not frustrated by the plurality of

causes. On account of this the conclusion is reliable. Besides the number of instances required by this method is very small, viz., two instances of a phenomenon, a positive and a negative one, or two stages of one and the same phenomenon, namely the stage before the introduction or elimination of an agent, and secondly the stage after the introduction or elimination of the agent.

It is pre-eminently an experimental method

(2) This method is generally applied in experiment, and on account of this it is said to be pre-eminently the method of experiment. The phenomena to which this method is generally applied are under our control so as to enable us to make elimination or introduction of an agent or circumstance possible. Generally elimination is not possible when the phenomena are not under our control, and even in those cases where elimination is possible we cannot be sure that the two instances agree in all respects save one. When instances are got by observation we cannot be sure that there is difference only in one point. For these reasons the Method of Difference is called the method of proof and is treated as the most reliable method.

It is a method of proof and is called the most reliable method.

All other methods may be treated af the special cases of the M. of Diff.

(3) All other methods indirectly satisfy the requirements of this method. In them we show with the help of different instances positive or negative or both that no one of the accompanying circumstances or agents can be treated as the cause of the phenomenon. This is what is demanded by the negative instances of the Method of Difference. In every method it is on account of the exclusion of the non-

causes that a causal relation can be established.

(4) On account of the efficiency of this method it has been remarked that one experiment successfully performed under this method is sufficient to establish a causal relation. But a prudent scientist and logician must not be satisfied with one experiment—he should repeat his experiment several times in order to be satisfied with the genuineness of his conclusion and to detect if there be any hidden agent or circumstances introducing error in the experiment.— C. Read.

From one experiment done acc. to this M we can establish a causal relation.

It is not vitiated by hidden agents when the instances are got by experiment.

(5) Almost all the methods are frustrated by non-observation or hidden agents and circumstances. But this method is not ordinarily vitiated by hidden agents because the phenomena to which this method is applied are determined by us, and are under our control. The conditions determining the phenomena are also completely known in these cases. But when we apply this method to instances gathered by means of observation then it is likely to be vitiated by non-observati on or hidden agents. In magic we find that an object dissappears when the magician touches it with his wand. According to the Method of Difference the magician's wand becomes the cause of the dissappearance of the object, but as a matter of fact we know that the sleight of hand or some secret manipulation is the real cause of the dissappearance of the object.

(f) **Defects.**

(1) The greatest defect of this method is that though the number of instances required by this

It is very difficult to fulfil the simple requirements of this method.

method is very small and the requirements of this method are very simple yet it is very difficult to satisfy this simple requirements of this method. This is because the instances of the phenomenon under investigation generally differ in more points than one while according to this method we require instances agreeing only in one point. So the scope of this method is very limited.

Its conclusion is modified by the plurality of causes.

(2) Though this method is not frustrated by the plurality of causes yet if we accept this doctrine the nature of the conclusion will be altered and the method will establish not **the cause** but **a cause**, i.e., it will establish one of the causes producing the phenomenon and not the one and the only cause.

It often treats a condition as the total cause.

(3) Another great defect of this method is that it pretends to treat a condition as a total cause, e.g., the cutting of the string is treated as the cause of the falling of the punkah. Sometimes according to this method we treat one of the co-effects as the cause of the other, e.g., the flash of light is treated as the cause of the report of the gun.

It does not prove the transference of energy.

(4) This method overlooks the quantitative aspect of the causal relation, and now-a-days it is not reasonable to establish a causal relation between two phenomena without knowing definitely that there is the transference of energy from the one to the other.

(5) This method is not generally applicable to arguments in which we proceed from the effect to the cause. The misapplication of the method

The mis-application of this method gives rise to fallacy.

is very common, and so this method gives rise to the popular fallacy of *post hoc ergo propter hoc*, e.g., with the arrival of a governor in a province the weather became very bad, and so the people thought that the bad weather was due to that governor. Similarly it is fallacious to maintain that a bride is the cause of a mishap in a family if it happens after the arrival of the bride into the family.

(g) The Method of Agreement compared with the Method of Difference.

(i) Both the methods are deduced from the scientific view of causation which we know combines within it the law of causation and the uniformity of nature. But the Method of Agreement rests on the principle that whatever antecedent can be eliminated without prejudice to the effect cannot be considered to be the cause while the Method of Difference rests on the principle that whatever antecedent cannot be left out without affecting the effect must be causally connected with it provided no other change takes place along with its elimination. Both these principles follow from the scientific view of causation. In both these methods the cogency rests on elimination. Therefore both of them may be treated as methods of elimination.

(ii) The Method of Agreement requires instances like the following :—

ABC followed by **pqr**

ADE followed by **pst**

AFG followed by **puv**.

Here we can establish a causal relation between A

and **p** because the possibility of **B, C, D, E, F, G,** being regarded as the cause of **p** is eliminated because when they are absent **p** freely occurs.

The Method of Difference requires instances like the following :—

ABC followed by **pqr**

BC followed by **qr.**

Here we can conclude that **A** is the cause of **p** because the possibility of **B** and **C** being regarded as the cause of **p** is eliminated for when they occur **p** does not occur. Therefore both the methods are methods of elimination and rest on the elimination of the probable causes save one. But as elimination supposes detection so these methods may be treated as methods of detection or discovery as well. So these methods have two aspects of which one is positive and the other is negative.

(iii) Both the methods rest on agreement as well as difference. The Method of Agreement is not a method of pure agreement because in it we require instances differing in all respects save one. The Method of Difference is not a method of pure difference because in it we require instances agreeing in all points save one. Pure agreement and pure difference exist neither in thought nor in the outside world of nature.

(iv) The Method of Agreement is mainly a method of observation while the Method of Difference is mainly a method of experiment but both the methods can be used in experiment and obser-

vation. But when experiment is possible no one thinks of applying the Method of Agreement.

(v) The Method of Agreement ordinarily requires a large number of instances whereas only two instances or two stages of one and the same instance are required by the Method of Difference. The negative instance of the phenomenon under investigation is considered by the Method of Difference and so the conclusion is reliable, while the Method of Agreement does not consider any negative instance of the phenomenon under investigation, and so it can prove only probable conclusions.

(vi) The Method of Agreement is vitiated by the plurality of causes but the Method of Difference is not frustrated by the plurality of causes. Even when we accept the plurality of causes we can establish one of the causes by applying the Method of Difference. Hence the Method of Difference is more reliable than the Method of Agreement.

(vii) Both the methods suggest hypothesis and rest on hypothesis and are vitiated by the intermixture of effects. The scope of the Method of Agreement is greater than the scope of the Method of Difference but as a method of proof the value of the Method of Difference is considerably greater than that of the Method of Agreement. The function of the Method of Agreement is to suggest good hypotheses while the function of the Method of Difference is to prove the hypotheses suggested by the Method of Agreement. Thus both the

methods are inter-related and one of them prepares the ground for the application of the other.

Points of agreement.

(h) **The Method of Difference and the Joint Method compared.** It has been pointed out already that all the experimental methods have been deduced from the scientific view of causation and they express the different aspects of the causal relation. Hence the Joint Method and the Method of Difference rest on the same basis. In both of them we establish a causal relation by eliminating the possible rival hypotheses. Both of them consider the negative instance of the phenomenon under investigation, and neither of them is frustrated by the plurality of causes. Hence both these methods are reliable methods.

Points of difference.

When we gather our instances by observation or when the phenomenon under investigation is beyond our control we try to apply the Joint Method, but when the instances are gathered by experiment or when the phenomenon studied is under our control we try to apply the Method of Diffence. The Joint Method is called an observational method, while the Method of Differerence is called an experimental method. Nobody thinks of applying the Joint Method when experiment is possible. The Method of Difference is pre-eminently the method of discovery. The Joint Method requires a set of positive instances *differin6* in all respects save one, and a set of negative instances *differing* in all respects save one, while the Method of Difference requires two

instances only, viz., a positive and a negative instance *agreeing* in all respects save one. *The difference between these two methods lies on the nature of the instances required by them.* The Joint Method indirectly fulfils the requirements of the Method of Difference, for in the negative set the accompanying phenomena are all present, and we can mentally construct out of them a relation like BC followed by qr. In the Joint Method we generally proceed from the effect to the cause, while in the Method of Difference we proceed from the cause to the effect. In both these methods the conclusion is grounded not on the *number* of instances but on their *nature*. Yet great importance is placed on the number of instances in the Joint Method simply because the instances are derived by observation, and as such they agree in more points that one. While a single-experiment successfully made according to the Method of Difference is sufficient to establish a reliable conclusion.

Which of them is more reliable?

Both the methods are frustrated by hidden agents and intermixture of effects. and by both of them we are led to treat (a) a part of the cause as the total cause, and (b) the co-effects as cause and effect. No one of these methods can establish the total or unconditional cause, or the only cause and so the claim of Flower that the Joint Method is superior to the other methods as by it we can establish the only cause is entirely wrong. When the plurality of causes is accepted, like the Method

Fowler's criticism is not correct.

of Difference, only one of the causes, i. e. *a cause* and not *the cause*, can be established by the Joint Method. For we may have hundreds of separate groups of instances establishing hundreds of causes of one and the same phenomenon. Unless and until the phenomenon under investigation is specialised we cannot get rid of the plurality of causes. Such a specialisation is possible in experiment and so in the application of the Method of Difference but not in observation and so not in the application of the Joint Method. For this reason the Method of Difference is considerably more reliable than the Joint Method.

Both the methods totally overlook the quantitative aspect of the causal relation, and so both of them should be supplemented by the Method of Concomitant Variations. Even after the application of these methods we should try to make the supposed cause independently produce the supposed effect when they are under our control. Without this further experiment our conclusions will remain probable in the logical sense.

(iv) **The Method of Concomitant Variations.**

(a) **Definition.** *Whatever phenomenon varies in any manner whenever another phenomenon consequent or antecedent varies in some particular manner (no other change having occurred) is either a cause or effect of that phenomenon or is connected with it through some fact of causation.*

(b) **Symbolical illustration.** This method can be illustrated in two ways :—

(1) When the accompanying circumstances remain unaltered.

If **ABC** be followed by **pqr**,
if **2A, BC** be followed by **p′qr**,
and if **3A, BC** be followed by **p″qr**,

then according to the Method of Concomitant Variations we can conclude that **A** is the cause of **p** or is causally connected with it

Principle underlying this method.

Here we notice that whenever **A** is changed into 2A and 3A, **p′** changes correspondingly into p′ and **p″**, and the other circumstances remain unaltered. Therefore the variations in **p** must be due to the variations in **A**. We have seen already that two phenomena cannot be treated as cause and effect if one of them remains constant when the other varies. According to this principle B and **C** cannot be treated as the cause of **p** because when **p** varies they remain unaltered.

It is a special case of the M. of Difference.

In this case the Method of Concomitant variations becomes a special case of the Method of Difference In the symbolical example mentioned above we find that the instances differ only in the quantity of **A** and **p.** Therefore we can conclude according to the Method of Difference that the quantitative difference in A is the cause of the quantitative difference in p. In this case the conclusion arrived at is reliable.

Concrete illustration. If in a cup of tea we go on increasing the quantity of sugar without introducing any other change then we shall find that the sweetness of the tea goes on increasing.

Hence according to this method this sweetness of tea is due to sugar.

(2) When the accompanying circumstances vary qualitatively.

If **ABC** be followed by **pqr**,

if **2A, DE** be followed by **p′st**

and if **3A, FG** be followed by **p″uv**,

then according to the Method of Concomitant Variations we conclude that A is the cause of **p** or is causally connected with it

Here B, C, **D**, E, **F**, and **G** cannot be treated as the cause of **p** because when they are absent **p** occurs. Hence **A** alone can be treated as the cause of **p** and the variations in the quantity of energy in **p** must be due to the variations of energy in A.

It is a special case of the M. of Agreement.

In this case the Method of Concomitant Variations becomes a special case of the Method of Agreement because all the positive instances of **A** differ in all respects save one, namely the consequent **p**. Hence the Method of Agreement tells us that in such a case we can establish a causal relation between A and **p**. In this case the conclusion established becomes probable and is completely frustrated by the plurality of causes.

Defects of this case.

How Mill's definition has been improved.

To avoid the second case of this method, namely when the accompanying circumstances vary, and to make the conclusion reliable many logicians insert within the definition of this method the expression "*no other change having occurred*". When this is inserted within the definition this method admits of only one kind of illustration.

The peculiarity of this method.

The other methods are qualitative in nature whereas this method is quantitative. From the other methods we get the information that A is the cause of **p**, but these do not tell us how much of A produces how much of **p**. It is the Method of Concomitant Variations which gives us this additional information. Hence the greatest value of this method is to specifically determine the quantity of the cause necessary for the productionof a given pnenomenon.

The cause and the effect are made precise by this method.

Concrete illustration : We find that the more the friction the more is the heat and so we conclude according to this method that friction is the cause of heat or is causally connected with it. Again we find that the more the heat of an object the more is its volume and so according to this method heat is causally connected with the volume of an object. These two cases illustrate *direct* variation. Again we find that the more the heat the less the density, and so according to the Method of Concomitant Variations we conclude that there is a causal connection between temperature and the density of objects. Again we find by observation that the more the moral culture the less the number of crimes committed by the people having this culture. Hence according to this method there is a causal connection between the moral culture and the number of crimes committed by a people. These two instances illustrate *inverse* variation.

Here a little explanation as to the nature of

variation is necessary Two phenomena are said to vary together when the variations in one are determined by the variations in the other. In such cases the variations in the one bear a proportion to the other. Such variations may be either *direct* or *inverse*. Two phenomena are said to vary *directly* if one of them increases while the other increases, and if one of them decreases while the other decreases, e.g., the more the proverty the more is the misery, and the less the proverty the less the misery. Hence there is direct variation between poverty and misery. Two phenomena are said to vary *inversely* when we find that one of them increases while the other decreases, and one of them decreases while the other increases. We have such a variation between the denotation and the connotation of a term. Two phenomena are said not to vary together when one of them varies while the other remains constant, or when they vary in no proportionate manner. As for instance when the chair is moved the table remains unchanged. Hence they are said not to vary together. We find that the water of the Ganges is always changing and the trains on the rail road are also changing but they are not changing in any proportionate manner. So they are said not to vary together. In such cases there cannot be any causal relation.

Two kinds of variation:

direct and inverse.

(c) **The Principle on which this method is based.** It is a development of the quantitative aspect of the causal relation which maintains that

the quantity of energy in the cause is *equal to* and *identical with* the quantity of energy in the effect. Therefore any variation in the quantity of the cause must imply a corresponding or concomitant variation in its effect. From this it follows that "nothing is the cause of a phenomenon which varies when it is constant or is constant when it varies or varies in no proportionate manner with it."

(d) **Criticism of the Method.**

The effect of permanent causes are found out by this method alone.

Merits. (i) The greatest use or peculiarity of this method lies in the fact that it is the only method with which we can tackle the **permanent causes** or those agents or phenomena which cannot be completely eliminated but can be had in various degrees, e. g., gravity, friction, atmospheric pressure etc. The Method of Difference requires the elimination of the phenomenon under investigation. So with its help we cannot ascertain the effect of any permanent cause. For the same reason the Joint Method is not applicable to the permanent causes.

We can establish the effects of permanent causes by the Method of Agreement.

In the Method or Agreement the elimination of the accompanying circumstances is required. When the permanent causes are taken into consideration the instances required by the Method of Agreement will agree in more points than one. But if we want to ascertain the effect of any permanent cause by the Method of Agreement then of course a conclusion is possible, e g., by the Method of Agreement we conclude that heat is the cause of the melting of oily substances. But with its help we cannot quantitatively determine the cause or the effect.

(2) The second great use of the Method of Concomitant Variations lies in the fact that with its help we quantitatively determine the cause and the effect, i.e., we show how much of a cause is necessary for producing a definite quantity of a phenomenon or effect.

It makes causal relations precise.

(3) The third use of this method lies in the fact that with its help we show the transference of energy from the cause to its effect without which a scientific causal relation cannot be established now-a-days. Thus after applying the Method of Difference which is treated as the most reliable method we should invariably apply the Method of Concomitant Variations.

It shows the transference of energy.

(4) This method is generally treated as a method of discovery. Suppose a person takes a kind of food and holds that it is not harmful. By increasing the quantity of this food if we find that some painful sensation is caused or some illness is produced then we can at once conclude that the food is harmful. When by accident a thing is taken in an excessive quantity and the person taking it falls ill immediately then of course a causal relation can be established between that food and illness. This shows the efficacy of the extreme case in discovering the causal relation.

It is a method of discovery.

Efficacy of the extreme case.

Defects.

(1) The greatest defect of this method lies in the fact that the conclusion established by it is not universal in nature, i.e., it holds good between some limits, e.g., by applying this method we conclude that

It fails to prove a universal law.

the more the heat of water the less the volume. and the less the heat of water the less is its volume. But if we go on decreasing the heat of water we find that its volume also goes on decreasing. But suddenly at a particular point the volume, instead of decreasing, increases considerably. and water becomes converted into ice. Similarly the more the stimulus the more the sensation. But we find that the sensation ceases to increase at a certain point when the stimulus is made to increase.

Difficulty is also felt in applying this method where quantitative variations introduce qualitative change, e.g., by applying heat to water it can be transformed into vapour. Here we have a change in quality and so the phenomenon passes out of the scope of this method.

Sometimes Co-effects are treated as cause and effect by this method.

(2) By this method we are often misled to regard co-effects as cause and effect, e.g., the more the water in the Ganges the more is the current, and the less the water, the less the current. So according to this method we may conclude that the water in the Ganges is the cause of its current. But we know that they are the co-effects of heavy rainfall on the mountains, the melting of glaciers, and gravity. Similarly the more the death of rats the more is the plague and the less the death of rats the less is the plague. Hence according to this method the death of rats becomes the cause of plague, but they are really the co-effects of the biting of a kind of flea. Again the more the fall of the mercury column in the barometer the more is the

violence of the ensuing storm, and so according to this method the former becomes the cause of the latter. But we know that they are the co-effects of the fall of atmospheric pressure.

(e) **The Method of Concomitant Variations compared with the Method of Difference.**

The Method of Concomitant Variations becomes a special case of the Method of Difference when the accompanying phenomena remain the same, that is when we insert in the definition the expression *"no other change having occurred"* after 'some particular manner.' But when the accompanying phenomena vary along with the variations of the phenomenon under investigation it cannot be regarded as a special case of the Method of Difference. Even in the first case where the accompanying phenomena remain unaltered we can establish a quantitative relation directly but not a qualitative relation as is establish by the Method of Difference. Besides in the Method of Difference we take a negative instance of the total phenomenon under study, while we take a negative instance of only a small quantity of the phenomenon under investigation in the Method of Concomitant Variations. It is for this reason we can prove by the Method of Difference that **A** is the cause of **p**, while by the Method of Concomitant Variations we can directly prove only that the quantitative variations in **A** are causally connected with the quantitative variations in **p**. But quantitative variations are not uniform throughout, therefore we cannot establish any uni-

versal law by the Method of Concomitant Variations, but we can establish a universal qualitative law by the Method of Difference. Hence the Method of Difference is more reliable than the Method of Concomitant Variations.

The Method of Difference is not applicable to permanent causes, i.e., when we are required to find out the effect of a permanent cause which cannot be eliminated we cannot apply the Method of Difference which requires the complete elimination of the phenomenon under investigation. But we can find out the effect of the permanent causes by applying the Method of Concomitant Variations.

The Method of Concomitant Variations is a fruitful source of hypothesis, and the function of the Method of Difference is to establish the hypothesis suggested by the Method of Agreement and the Method of Concomitant Variations. Therefore the Method of Concomitant Variations is called the method of discovery while the Method of Difference is called the method of proof.

In many cases the result of the Method of Difference is further strengthened by the application of the Method of Concomitant Variations. We have seen already that the Method of Difference fails to prove the transference of energy from the cause to the effect, or to show the quantitative equivalence between them. We have only the Method of Concomitant Variations to show the transference of energy. Hence the application of this method is imperative in every case as without it the quanti-

tative aspect of the causal relation cannot be proved.

The Method of Concomitant Variations is most regular within the *medium range,* i.e., between certain critical points, while the Method of Difference establishes conclusions which hold good universally

(v) **The Graphic Method.**

Quantitative variations can be represented with the help of a graph or a picture whereas qualitative variations cannot be so represented. So we can represent with the help of a graph the variations of the phenomena considered by the Method of Concomitant Variations, and then we can draw conclusions from that graph very easily. Now when the instances are so represented with the help of a graph and the conclusion is drawn on the strength of that graph then the Method of Concomitant Variations becomes the **Graphic Method.** The Doctors apply this graphic method when the patient suffers from typhoid. Along the horizontal line is measured and drawn one of the agents, or conditions with which the enquiry is concerned, It is called the **variable** and along with the perpendicular is measured and drawn some other phenomenon which we want to compare with the variable. This second phenomenon is called the **variant.** The graph itself shows whether there is any corresponding variation between the two phenomena. Thus the Graphic Method exhibits concomitant variations to the eye and is extensively used in

It is a good method of discovery but not of proof.

It helps us in detecting factors which vary together.

The variable and the variant.

physical and statistical enquiry. It is therefore also called the Statistical Method.

All these follow from the M. of Concomitant Variations

The Method of Concomitant Variations also gives rise to the **Serial Method** or **the Method of Gradations** or **the Comparative Method.** These are really the different names of one and the same thing. In them instead of representing the varying phenomena with the help of a graph we are required to arrange the instances in a series or according to their grades of variation, from the highest form to the lowest form, and then it becomes clear whether there is any other phenomenon which varies along with the variation of the objects in the series. When the instances are not arranged in a series the second factor of the variation, i.e., the variant, cannot be easily detected. Hence the efficacy of the Method of Series or Gradations is to help us in discovering the factors that vary correspondingly which otherwise remain obscure. Hence these are the methods of discovery and not of proof. These may be treated as the subsidiary devices for discovering the instances required by the Method of Concomitant Variations. Special and separate recognition of these methods is not only unless but often misleading.

(vi) The Method of Residues.

(a) **Definition :** *Subduct from any phenomenon such part as previous inductions have shown to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedent.*

(b) **Symbolical illustration :**
If **pqr** follow **ABC**,
and if by previous induction we know that **q** is the effect of B, and **r** is the effect of **C**, then according to the Method of Residues we conclude that the residual phenomenon, **p**, is the effect of the remaining antecedent, A.

Here we notice that we have only one instance of succession actually observed by us and from this one case of succession we establish a causal relation with the help of the results arrived at by previous induction. Hence unlike the other methods this method is not an independent method.

(c) **Concrete illustrations** : (1) When we try to explain our system of knowledge we find that almost the whole system can be explained by experience and inference. But a fragment of it cannot be so explained. So according to the Method of Residues it is inferred that this fragment is due to a different source, viz., intuition.

This is not an independent Method

(2) We know that the planets move on account of the attractions of the sun and other heaventl bodies of the solar system. The orbit of the planet Uranus was at first explained by the astronomers with reference to the influence of the known planets upon the Uranus. In other words it was found by calculation that on account of the influence exerted by the known planets the Uranus should move in a definite path. But it was actually found that the Uranus deviates from this calculated path a little. This deviation is therefore a residual phenomenon which cannot be

Discoveey of the Neptune.

explained by the known planets. So it was inferred that this deviation was due to some unknown planet existing in some part of the sky. By directing the telescope to that part of the heavens a new planet was actually discovered, and this new planet was given the name Neptune.

It is a Method of discovery.

This illustration shows that this method is a method of discovery, and at best it suggests a hypothesis to be proved later on by observation or experiment. It also shows that all the antecedents of the phenomenon under investigation are not present before us. In the symbolical illustration all the antecedents, viz., ABC, are known. and the cause is to be found out from amongst these antecedents. But in practical investigation the antecedents are known partially and the cause to be found out remains hidden. To cover all these causes the method can be defined in the following manner :—

Modified definition of the Method to cover the cases of hidden agents or causes.

A phenomenon which cannot be explained by the known causes must be the effect of some unknown cause or nothing can be treated as the cause of a given phenomenon which is found to produce a different effect.

Discovery of Argon.

(3) Argon has been discovered by applying this method. It was found that natural nitrogen is heavier than nitrogen artificially prepared in the laboratary. By the Method of Residues it was inferred that the excess weight in natural nitrogen must be due to some heavier chemical which remains mixed up with it. By careful analysis of natural

nitrogen a new heavier chemical was actually discovered, and was given the name argon. In this case also we find that the Method of Residues simply suggests a hypothesis to be proved later on by actual observation or experiment.

It follows from the Method of Difference.

Criticism. (1) This method is really a special case or corollary of the Method of Difference in which we require a positive and a negative instance of the phenomenon agreeing in all respects save one. In the Method of Residues also we require two instances of which one is actually present before us, while the other namely the negative instance is mentally constructed with the help of previous induction. The Method of Difference requires instances like the following :—

Difference between the two methods.

ABC followed by **pqr** (actually observed),

BC followed by **qr** (actually observed)

But the Method of Residues requires instances like the following :—

pqr follow ABC (actually observed),

qr follow BC (mentally constructed).

We know from previous induction that **q** is the effect of B and **r** is the effect of C and there being a case of succession between the cause and its effect we mentally construct that **qr** follow BC. But ordinarily in our investigation with the Method of Residues we have not all the antecedents present before us. In the symbolic illustration the antecedents ABC are fully given and the cause A is observed along with other antecedents. But in actual investigation A remains hidden, and we are required

to find it out by laborious research. This is clear from the ways in which the planet Neptune and the chemical argon have been discovered.

(2) The Method of Difference is an independent method, and does not take the help of previous induction. It proceeds from the cause to the effect. But the Method of Residues is a dependent method as it takes the help of previous induction. In it we proceed from the effect to the cause.

Is it baffled by the plurality of causes?

(3) When the plurality of causes is accepted we cannot infer the cause from the effect, and so we cannot proceed from the consequent to the antecedent as we are required to do in the Method of Residues. For this reason the plurality of causes seems to frustrate the Method of Residues, but the Method of Difference is not frustrated by it. In the Method of Residues the conditions being fully known and being completely under our control the plurality of causes cannot frustrate our conclusion though theoretically it raises insurmountable difficulty.

All the methods are the special cases of this method.

(4) In one sense all the methods are special cases of the Method of Residues because in all of them we start with a number of hypotheses, e g., either A or B or C or D is the cause of **p**, and then with the help of the instances, positive or negative or both we show that B, C, D etc., cannot be the cause of **p**. So the remaining hypothesis or antecedent must be the cause of **p**. In other words, it is the elimination of the non-causes which authorises us to establish a causal relation between a phenomenon and the remaining antecedent.

(5) The main function of the Method of Residues is to supplement other methods. Though it is the method of discovery yet it is widely used in experiment. When in any experiment we find some excess or deviation or defect then in order to explain this excess or defect we generally apply the Method of Residues, e. g., the excess in the weight of natural nitrogen over artificial nitrogen was explained by the Method of Residues. The deviation of the Uranus from the calculated path was also explained by the Method of Residues. It is also used in observation when we explain most of the cases of typhoid in a particular town by the hypothesis that the milk supply is the cause of the typhoid, we require the help of the Method of Residues in order to explain the remaining small number of cases where apparently the milk supply in question does not operate.

Where is this method used?

(6) This method establishes a causal relation from a single case of succession. On account of this it is very risky to be definitely sure of the validity of the conclusion arrived at by this method. It is greatly frustrated by hidden causes, and unless and until we are sure that the phenomenon under investigation is fully determined it is not advisable to apply this method. So logically we should apply this method in connection with experiments in which all the circumstances are fully known.

Defects.

It is frustrated by hidden agents.

(7) When a part of the cause is viewed as the total cause and when a part of the effect is viewed

as the total effect then we are sure to establish erroneous conclusion by this method, and treat a part of the effect of a known cause as the residual phenomenon requiring unknown causes for its explanation. To guard against all such errors it is advisable for us to apply the Method of Difference after applying the Method of Residues or after discovering the cause by the Method of Residues.

(8) This method does not show any transference of energy from the supposed cause to its effect nor does it prove their quantitative equivalence. For realising this end we should supplement the Method of Residues with the additional application of the Method of Concomitant Variations.

Thus we find that though the Method of Residues appears to be a very easy simple and method (as easy as mathematical subtraction), yet it is the most difficult method, and so it can be successfully applied only in experiment where the circumstances are fully known.

4. **The Unity of the Methods.**

There are altogether five methods. Of these the Method of Residues is a corollary of the Method of Difference, and the Joint Method is a special case of the Method of Agreement and an improvement upon the Method of Agreement. Therefore there are three fundamental methods, viz, the Method of Agreement, the Method of Difference, and the Method of Concomitant Variations. The Method of Concomitant Variations also becomes a special case of Method of Agreement when the

accompanying circumstances vary qualitatively along with the quantitative variations of the phenomencn under investigation. It becomes a special case of the Method of Difference if the accompanying circumstances remain unaltered when the phenomenon under investigation vary quantitatively. Thus we conclude that of the five methods the Method of Agreement and the Method of Difference are the fundamental methods. The Method of Agreement gives us probable conclusions and is not a method of proof as it does not consider any negative instance of the phenomenon under investigation. Its real function is to suggest a good hypothesis in order to be proved later on by the Method of Difference which is a reliable method and is not frustrated by the plurality of causes. Hence the most fundamental and reliable method is the Method of Difference. In it we have directly a negative instance of the phenomenon under investigation in which all the accompanying circumstances occur, and the negative instance shows that no one of the accompanying circumstances can be treated as the cause of the phenomenon under investigation, because when they are present it is absent, while in the other methods we indirectly get the negative instances to show that when the accompanying circumstances are absent the phenomenon under investigation is present (as in the Method of Agreement). Thus we conclude that the most fundamental and reliable experimental method is the Method of Difference.

The most fundamental and reliable method is he Method of Difference.

All other methods indirectly fulfil the requirements of this method.

The Method of Agreement is also a necessary method.

But for for this reason we cannot dispense with the Method of Agreement, because the application of the Method of Difference requires a good hypothesis and for such a hypothesis we invariably require the Method of Agreement. Hence it is not incorrect to say that both the methods are necessary and fundamental. Besides the scope of the Method of Difference is limited, whereas there is no limit to the scope of the Method of Agreement. Most of the popular generalisations and the principles which we follow in practice are grounded on the Method of Agreement. Hence they are probable in nature. Our life is highly complex and it is not possible for us to get concrete principles having the certainty of the conclusions established by the Method of Difference. Our life is generally conducted according to the probable principles arrived at by the Method of Agreement. Hence the practical value of the Method of Agreement is very great.

Agreement and difference lie at the bottom of all inference.

The Method of Agreement is not a case of pure agreement but it considers instances agreeing only in one point, while the Method of Difference is not a case of pure difference because it requires instances agreeing in all points save one. This shows that agreement and difference lie at the bottom of all inference. But here agreement and difference do not mean the experimental methods of Agreement and Difference.

5. The Methods of Observation, Experiment, Discovery, and Proof.

By the Experimental Methods we mean the

Method of Agreement, the Joint Method, The Method of Difference, the Method of Concomitant Variations, and the Method of Residues. They are called *experimental* because they show the fundamental method which the scientists follow, and ought to follow in performing as experiment. We have seen that in these Methods we vary the accompanying circumstances, take the positive and negative instances of the phenomenon under investigation, and vary them also quantitatively in order to establish a causal relation between two phenomena. In all the ethods it is the elimination of the non-causes or rival hypotheses which enables us to establish a causal relation. So these Methods may be treated as the methods of eliminating the non-causes with a view to detect and prove a causal relation. These Methods also tell us the various ways in which we may vary the circumstances in the midst of which a phenomenon occurs. Thus these Methods describe the characteristics of the antecedents and consequents which enable us to establish a causal relation, and eliminate the non-causes.

Why are they called Experimental methods?

Methods of elimination.

The conditions required by all the Methods seem to be so simple that we may fulfil them by facts derived either from Observation or Experiment. But actually it is very difficult, if not impossible, to satisfy these simple requirements by the facts and phenomena derived from Observation for three reasons, viz., (i) in Observation neither the antecedents nor the consequents are fully known; (ii) the facts and phenomena derived from Observa-

Can we fulfil the requirements of these methods?

tion either agree in more respects than one or differ in more points than one, and their variations cannot be precisely measured; and (iii) in many cases we fail to isolate or eliminate a phenomenon which we are required to do according to these Methods. Hence the Methods can be accurately applied only to phenomena got by Experiment and so they are called Experimental Methods.

Methods of Experiment and Observation distinguished.

Yet all these Methods are applied to phenomena derived from Observation where their requirements can be only partly or approximately fulfilled. When thus applied the Methods establish probable conclusions only, and are for this reason treated as Methods of Discovery and not of Proof. When they are applied to facts and phenomena derived from experiment they all establish reliable conclusions and are for this reason treated as Method of Proof and not of Discovery. But to prove a causal relation is to discover it. We cannot be said to discover a causal relation unless we are sure of this relation, i. e., unless we are able to proove it. Hence the division of the Methods into the Methods of Observation and the Methods of Experiment, and again into the Methods of discovery and the Methods of Proof is erroneous. Similarly it is not correct to say that the Methods are all Methods of Elimination only, for in every case this elimination leads to the detection of the causal relation. Hence the Methods have both positive and negative aspects.

Method of Proof and Discovery distinguished.

When experiment is possible we invariably apply the Method of Difference, and in order to make the cause and its effect quantitatively precise

we apply also the Method of Concomitant Variations. If there be any residual phenomenon in the from of excess or deficiency we further apply the Method of Residues. But we never think of applying the Method of Agreement or the Joint Method in experiment. Hence the Method of Difference, the Method of Conconinant Variations, and the Method of Residues are treated as the Methods of Experiment. While the Method of Agreement and the Joint Method are treated as the Methods of Observation. But it should be always remembered that the first three can be applied to observation, and the last two can be applied to experiment. Hence it is more correct to maintain that all these Methods are both Methods of Observatson and of Experiment, but the Method of Difference is pre-eminetly the Method of Experiment and Proof.

The Method of Difference is the method of experiment.

and

the method of Agreement is the method of discovery.

When we are required to find out the cause of a phenomenon experiment is not possible. Again when the given phenomenon is either beyond our control or is too dangerous experiment is not possible. In such cases we have to apply either the Method of Agreement or the Joint Method and to rely entirely on Observation. Hence these two Methods are called the Methods of Observation. The Method of Agreement does not consider any negative instance of the phenomenon under investigation, and is frustrated by the plurality of causes Hence it establishes probable conclusions. For these reasons it is pre-eminently the Method of Observation, and of Discovery. While the Joint

There are many cases where the Method of Difference cannot be applied.

Method considers negative snstances of the phenomenon under investigation, and is not frustrated by the plurality of causes, and so its conclusions are reliable. For this reason the Joint Method is treated as a Method of Proof though it is mainly a Method of Observation. The Method of Concomitant Variations and of Residues are supplementary Methods. They are applied in connection with both Observation and Experiment. The Method of Concomitant Variations is one of the greatest sources of hypothesis. Its conclusions hold good within a limited range. So it is ordinarily treated as a Method Discovery and of Observation though it is widely used in connection with Experiment and may be treated as a Method of Experiment for this reason.

The Joint Method is a method of observation and proof.

The method of Residues is widely used in connection with Experiment. Thus applied it gives us reliable conclusions. It can be applied also in Observation but in this case we ordinarily get probable conclusion. In this Method we ordinarily proceed from the effect to the cause which becomes impossible when the plurality of causes is accepted. Even when it is applied in connection with experiment it suggests only the presence of an unknown cause, and to prove this we require the help of further analysis, observation or experiment. Hence this Method should be treated as a Method of Discovery and of Observation though it is widely used in connection with experiment.

Is the Method of Residues a method of experiment?

Is it a method of proof ?

All these Methods are sometimes called the

Direct Methods of Induction because according to them we are required to gather facts and phenomena, and then to establish a causal relation by directly applying these Methods to them. Thus there seems to be no necessity for forming any hypothesis and the exclusion of the rival hypotheses. But this is impossible because without the help of some hypothesis it is impossible for us to gather the necessary facts and phenomena, and without the exclusion of the rival hypotheses it is impossible to apply the Method. These rival hypotheses appear as accompanying phenomena in all the Methods. All through these Methods the help of hypothesis is taken, and the conclusion becomes possible on account of the elimination of the rival hypotheses. Hence there is very little truth in treating these Methods as the Direct Methods of Induction.

The direct methods of induction.

6. Criticism of the Methods.

The following charges have been brought against these Methods by different logicians. Let us exmine them one by one.

(1) *The Methods take for granted the very thing which is most difficult to discover*, viz., the reduction of the complex phenomena to simple formula showing simple ansecedents and consequents like **ABC** followed by **abc**. Here it seems that we take for granted that **A** is the cause of **a**, **B** is the cause of **b**, and **C** is the cause of **c**. But these are the things which we are required to prove by the Methods (Whewell).

This criticism is unjust because by symbols we cannot show the complexity of the facts and phenomena of our experience. Inductive enquiry is a very difficult task, and as long as the complexity of the phenomena is not simplified by analysis and the exclusion of the irrelevant factors the Methods cannot be applied, and no causal relation can be established. The Methods show the goal which we should try to reach by means of analysis, synthesis, and elimination. Hence the Methods do not overlook the difficult preliminary task of simplifying complex phenomena. When the complexity cannot be simplified we apply the Complex Deductive Methods or the Doctrine of Chance but not these Methods. In symbolical representation different factors of the antecedents are bound to appear to be causally connected with the different factors of the consequents. But if it be treated as a defect of the Methods then we ought to condemn the Law of Causation itself which tells us that every event has a cause. Hence it is necessary to insert in the formulæ separate causal factors for the separate consequents. But from a single case of succession like **ABC** followed by **abc** it cannot be said that **A** is the cause of **a**. Hence it is incorrect to say that the Methods assume the very things which they want to prove.

(2) *No discovery has been made by the application of these Methods (Whewell).*

This criticism is also wrong because the methods which have been followed by the scientists in making

their discoveries can be reduced to one of these Methods. Chance discoveries and discoveries by deduction are not grounded on these Methods. But designed discoveries based on Observation and Experiment invariably follow the line of enquiry laid down by these Methods. Besides to make our discoveries free from doubt we are required to prove them. Hence as Methods of Proof these experimental Methods are always necessary if we want to establish a causal connection or to make a generalisation from experience. These Methods also tell us how much reliance we can place on the popular generalisations not grounded on these Methods.

(3) *The Methods are not Inductive in Mill's sense, for they only start from universals and their mode of reasoning is deductive throughout* (*Welton*).

This criticism is directed against Mill and not to the Methods and as such it involves the fallacy of *argumentum ad hominem.* Mill really abandons his empirical attitude when he inserts 'unconditionality' as a mark of causation, and deduces the Experimental Methods from the Law of Causation. But this is no ground for saying that the Methods are defective In all arguments the conclusion follows from the premises and fundamental principles. These deductive elements are present in all the Methods. But from this it is incorrect to say that the conclusion arrived at by these Methods follows deductively, i.e., syllogistically from the premises. Even if we can transform an Inductive

argument to the syllogistic form it is not proper to maintain that the Methods are all deductive or syllogistic in character, because in the syllogistic argument the material aspect of our reasoning is absent and the conclusion is not grounded on the exclusion of the rival hypotheses.

(4) *The Methods are the sole Methods of proof as claimed by Mill Not only this, they do not even furnish a valid proof at all (Welton).*

Here Welton combines many issues into one and thereby seems to commit the fallacy of Many Questions. Mill's criticism of the syllogistic reasoning has not been rightly understood by many logicians. I have tried to explain Mill's position in my Text-book of Deductive Logic. If we are to make a generalisation through the establishment of a causal relation no other method of proof can be thought of, and no other method has yet been discovered. To find fault with these Methods is to find fault with the Law of Causation. For the difficulty of the application of these Methods the Methods are not responsible. They fail to furnish a valid proof when the requirements of these Methods are not fully satisfied. For the mis-application of these Methods we cannot hold that the Methods are worthless. The Method of analysis and synthesis as well as the Hypothetical Method all rest on these Experimental Methods.

Thus we find that all these criticisms are groundless. But it should be admitted that it is very difficult to fulfil the requirements of these Methods

completely, and so it becomes impossible for us to attain mathematical certainty in inductive inves tigation.

7. Illustrations of the Methods.

(1) Investigation as to the cause os **Dew.**

In this case we proceed from a phenomenon to its cause and so Observation is our only resource. *Observation.* The first thing necessary for us is to make our idea *Analysis.* of dew precise and clear. For this purpose we ought to distinguish it from other phenomena such as rain, fog, and mist. By *observation, analysis, comparison* of all these phenomena we find that dew is the spontaneous deposition of moisture on the surface *Definition.* of material objects from no visible source either in the atmosphere or in the ground below or in the object on which dew is formed. This is also treated as the definition of dew for the purpose of our investigation.

Then we have to observe the circumstances in *Further observation and analysis* the midst of which dew takes place and to analyse these circumstances into their elementary factors. For this reason further observation and analysis are necessary. We find that dew takes place generally at night, in darkness and when the atmosphere and the surface of things are cold. Thus we are presented with four hypotheses as to the cause of *Formation of hypothesis.* dew, viz., nightfall, darkness, coldness of the atmosphere, and the coldness of the surface of the things on which dew is deposited.

Now by means of *crucial instances* we should

Exclusion of rival hypotheses.

see which one of these hypotheses should be rejected and which one may likely be true.

We find by observation that every night dew is not formed on the surfaces of things. Hence nightfall cannot be the cause of dew. We find also that dew is deposited in a moonlit night and even in the morning and before nightfall. So darkness cannot be the cause of dew. Had darkness been the cause of dew it would have been deposited even in a dark room. Had coldness of the atmosphere been the cause of the formation of dew then there would have been dew at all places and all things and also throughout the day and night. But as this is not the case coldness of the atmosphere is not the cause of dew. But it may be one of the necessary conditions for we find that all the cases of dew are the cases of cold atmosphere. So the Method of Agreement can be applied here, and by it we can establish the probable conclusion that the coldness of the atmosphere is causally connected with the formation of dew. But the coldness of the atmosphere is closely connected with the cold surfaces of the things and is external to the objects on which dew is formed and so the last hypothesis is preferred. Thus all the hypotheses except one are excluded. Let us see whether we can establish it by applying the experimental Method.

Application of the experimental methods:

Let us examine one night the temperature of the surfaces on which dew has been formed We find that in every case the surface is cooler than the surrounding atmosphere. These positive instances

of dew agree only with respect to the comparative coolness of the surface. Hence according to the Method of Agreement the comparative coolness of the surface becomes the cause of the formation of dew. But this conclusion is only probable as it has been established by the Method of Agreement.

The Method of Agreement.

The same night if we measure the temperature of those things on which dew has not been formed we shall find that the surfaces of these objects are not cooler than the surrounding atmosphere. Hence we can apply the Joint Method and arrive at the same conclusion. Here we should notice that the measurement of temperature with a thermometer cannot be called an experiment. This application of the Joint Method makes the conclusion more reliable.

The Joint Method.

Let us then expose one night two bars of iron of the same size, form, and matter and by means of an electric wire let us prevent the lowering of the temperature of one of the bars. We shall see that dew fails to be deposited on this bar but it becomes deposited on the other bar. Hence by the Method of Difference we come to the same conclusion.

The Method of Difference.

We also observe that the quantity of dew is not the same on every object. By measuring the temperature of the objects on which dew is formed we find that the less the temperature of the surface, the more is the deposition of dew. Hence by the Method of Concomitant Variations we conclude that there is a causal connection between the comparative coolness of the surface and the formation of dew.

The Method of Concomitant Variations.

The Method of Residues.

But we find by further observation that in many cases the surfaces of objects are cooler than the surrounding atmosphere yet no dew is formed on them, though all the furfaces on which dew is formed are cooler than the surrounding atmosphere. So we conclude according to the Method of Residues that there must be some unknown agent the absence of which frustrates the formation of dew. Further analysis of the circumstances in which dew is formed led to the discovery of water vapour in the atmosphere, the capacity of the atmosphere to keep in suspension a difinite quantity of water vapour at a particulrr temperature and the lower the temperature the less is this capacity.

Conclusion.

Thus we conclude that the comparative coolness of the surface snd the presence of an excess quantity of water vapour constitute the formation of dew. This explains all the instances without any exception. When there is no excess amount of water vapour in the atmosphere dew will not be formed even if a surface happens to be cooler than the surrounding atmosphere.

Final experiment.

Lastly we should perform an experiment with artificially produced saturated air and a cool object, say a plate of glass placed in an ice chest. Let us insert this plate in the saturated air. We shall find that dew becomes deposited on this glass plate. Hence we become rationally certain as to the truth of our conclusion.

In this illustration we see how all the Methods are applied in establishing the cause of dew.

(2) *Investigation as to the cause of the epidemic of typhoid in Camden Town in 1883.*

Observation and its record.

Mr. Murphy, the medical officer, made a plan of the town and noted therein the affected houses. Thus he observed the cases of typhoid and recorded the results of his observation. The definition of typhoid was known to him and so he was able to distinguish it from other allied maladies, viz., malaria, kala-azar, etc.

Further observation of the circumstances.

Then he observed the circumstances in the midst of which the epidemic occurred, and thereby formed four hypotheses, viz., (1) the Regent's canal (2) the water supply, (3) the insanitary condition of the affected houses, and (4) the milk supply. Then he found out crucial instances to exlude the erroneous hypotheses and to detect the right one.

Hypotheses

He found that the houses far away from the canal were affected and many on the canal were not affected. Hence the hypotheses of the Regent's canal was rejected. Then he examined the next hypothesis. He found that there were two water supplying companies and the houses supplied by both these companies were affected. Besides had water been the cause of the epidemic, it would have been more virulent. He should have examined the water consumed under a microscope, and had he found no typhoid germs in that water this hppothesis would have been entirely wrong.

Then he examined the hypothesis that the insanitary condition is the cause of the epidemic. He found that the houses where there was perfect

sanitary condition contracted the disease. Hence this hypothesis was treated as inadequate. Thus there remained only one hypothesis in the field, viz, the milk supply. It was found that 368 persons out of 431 attacked by the disease consumed milk supplied by one dairy firm, and the remaining persons had their milk supply from different persons. Closer examination revealed that these were middle men and they also got their milk from the same dairy firm. Now the Method of Agreement can be applied as all the cases of typhoid agreed with respect to the consumption of this suspected milk. But the accurate application of this method is not possible as many persons who consumed this milk did not contract the disease. The Joint Method also cannot be applied as the negative cases of typhoid were not the negative cases of the consumption of this suspected milk. The Method of Difference cannot be applied here as the phenomenon is too dangerous. There being no question of quantity the Method of Concomitant Variations cannot be applied. So in this case our conclusion cannot rise above probability Had the suspected milk been examined under a microscope and typhoid germs detected therein the conclusion could have been reliable. Instead of proceeding in this scientific manner the medical officer inspected the cows of the suspected dairy firm and found that some of the cows of that firm had been suffering from typhoid. Thus the transference of energy was explained and the conclusion that the milk supply was the cause

Application of the Methods.

Verification.

of the epidemic was established. But it was not explained how so many persons using that very milk escaped from contracting the disease. We may say now that the weakness of the fighting white corpuscles of the blood was another necessary condition of the disease. Where this condition was absent people did not contract the disease though they consumed the milk containing typhoid germs.

8 Exercises

1. What is Experiment? Why is it thought necessary to deal with the methods of experiment in Logic? State the Method of Agreement, giving symbolical and real examples. What is its characteristic defect and how may it be overcome?

2. State fully and clearly, in your own words, the Method of Concomitant Variations, with examples. On what cannon or principle is it based? Of what other Method is it a modification? Is it a method of observation or of experiment, or of both? In what class of cases is it the only possible inductive method and why?

3. State the Method of Residues fully; with examples, symbolical and concrete. Does it involve any element of Deduction? Show how it may lead to discovery of new antecedents. Give some examples of this.

4. State in your own words and illustrate with examples the Method of Difference. Show by means of common instances that the Method plays a great part in every day inferences. Suppose that

wherever there are anopheles mosquitoes, there is malaria but that malaria is found also where there are no mosquitoes : what conclusion can you draw from this ?

5. What is the Joint Method ? Illustrate it.

6. When is it necessary to employ the Joint Method of Agreement and Difference ? State and illustrate this Method by a concrete example.

7. When is it necessary to employ the Method of Concomitant Variations ? Explain and illustrate this Method, illustrating its various forms.

8. Explain how Plurality of Causes and intermixture of Effects affect the application of the Method of Agreement. What advantage has the Method of Difference over the Method of Agreement, and what advantage has the latter over the former ?

9. What are the two main principles involved in Mill's canons of the Experimental Methods ? What are the two ways in which the Method of Residues may be applied ?

10. Explain and illustrate the Method of Difference showing its close connection with experiment in practical life. Point out how a careless use of this method leads to the fallacy of *post hoc ergo propter hoc.*

11. What are the various canons of elimination? Show by concrete examples, how each of them furnishes a method of enquiry into causation ?

12. Explain giving a concrete example, the Method of Difference, and point out its relation to the Methods of Concomitant Variations and Residues. Explain the nature of phenomenon for the investigation of which the last two methods are particularly suited.

13. Give a concrete example of the Method of Concomitant Variations. Indicate the limitations of the Method. Explain the principle of the quantitative equivalence of cause and effect.

14, 'The Method of Concomitant Variations and the Method of Residues are modifications of the Method of Difference.' Explain and illustrate the above statement. Explain the cases in which each of these two methods is appropriately employed.

15. Explain and illustrate the difficulties which tend to frustrate the experimental Methods. How are they overcome ?

16. Name the Experimental Methods by which each of the following conclusions is arrived at :-

(a If a particular portion of the brain is removed, a particular part of the body is paralysed.

(b) The more a body is heated, the more it expands.

(c) Scarlet flowers have no fragrance.

(d) The increase in the number of crimes in a village is due to the removal of its Police station.

17. State the Principles of elimination, and explain their relation to the Experimental Methods.

18. Explain what is meant by saying that the Methods of Agreement and of Difference are mainly the methods of Observation and Experiment respectively. How does the Method of Difference differ from the Method of Residues ?

19. Name the Experimental Methods by which each of the following conclusions is proved, explaining applicability in each case :-

(a) Heat is the cause of the melting of ice.

(b) Coconut trees best flourish in places not far removed from the sea.

(c) Despotic government gardually disappears as the people become more and more educated.

(d) The weight of the load is the total weight less the weight of the cart.

20 Jevons points out the entire insufficiency of the Baconian Method to discover the more obscure and difficult laws of Nature. What is the

Baconian Method ? How does Mill depart from it in discovering the more obscure and difficult laws of Nature ?

21. Test the validity of the following inductive arguments, giving reasons and naming the experimental methods by which each is established :-

(a) It was found that nitrogen as it occurs in the atmosphere was slightly heavier than nitrogen as obtained from chemical sources. The cause of this difference in weight must be due to the presence of some other gas in the atmosphere.

(b) A conjuror produces wonderful results by different tricks on different occasions taking care to wave his wand in each case. Therefore the waving of his wand is the cause of the wonderful results.

(c) As soon as I came to this place my disease was cured. Therefore the climate of this place effected the cure of my disease.

(d) The only cause of the diminution of crimes is the abundance of food supply, for crimes increase with the growing scarcity of food-stuff.

22. The Method of Agreement is a method of discovery and the Method of Difference is a method of proof. Explain the significance of the above remark.

23. Test the validity of the following inductive arguments, giving reasons and naming the method by which each is established :-

(a) Cold applied to water in an iron vessel freezes it. Cold applied to coconut oil in a glass bottle freezes it. Therefore cold is the cause of freezing.

(b) If on a clear night a sheet or any other covering be stretched a foot or two above the earth, so as to screen the ground below from the open sky, dew will be found on the grass around the screen but not beneath it. The open sky therefore must be an indispensable antecedent of dew.

(c) Water is jointly conveyed into a tank by three pipes of unequal size at the rate of 10 gallons per minute. It is known that the first two pipes together admit water at the rate of 7 gallons per minute. Therefore the amount of water admitted by the third pipe is at the rate of 3 gallons per minute.

(d) The retention of an idea in memory becomes more tenacious with the frequency of its repetition and the inceased attention paid to it. The retention of an idea in memory depends therefore on attention and repetition.

24. What do you understand by the experimental methods? Why are they so called? Indicate the use of each.

25. Why is the Method of Difference applicable only to the spheres where experiment can be applied?

26. Name the Experimental Methods on which each of the following arguments is based, giving your reasons :-

(a) Two small pieces of blanket, exactly alike in all respects except that one is coloured white and the other black, are placed on a block of ice. After a certain time it is found that the black piece has sunk deeper into the ice than the white one. Therefore it is concluded that black absorbes more heat than white.

(b) A large number of birds have been examined and found to be without teeth. Therefore it is inferred that all birds are without teeth.

(c) A nation becomes more prosperous as it developes in an increasing measure habits of industry and prudence.

(d) One Sunday morning in a poor country parish there appears the surprising phenomenon of a half sovereign in the effertory; the clergyman knows by repeated experience that none of his flock

ever by any chance gives more than a silver three penny piece ; but he has perceived a stranger in the congregation, and therefore he concludes that he is the donor of the half sovereign.

(e) Intermittent fever is found only in places where there are marshes, even though they differ in every respect.

(f) Able men have generally very bad hand-writing, while good hand-writing is frequently found in men doing comparatively little mental work. Hence it is inferred that mental strain is the cause of poor penmanship.

(g) Both mosquitoes and cases of malarial fever have, in certain parts in Italy, in West Africa and elsewhere, become much rarer since these districts have been well drained. Is malarial fever the effect of the presence of mosquitoes ?

26. Discuss the principle underlying the Method of Difference. Give a concrete example. Show how far multiplicity of instances increases the probability of induction, so far as the Method of Agreement is concerned.

CHAPTER VIII

ANALOGY.

1. **The Meaning of Analogy.** Analogy is a probable reasoning in which we proceed from one particular object to another particular on the strength of similarity. As for instance we find that the planet Mars resembles the earth with regard to land, water, and atmosphere, and so by Analogy we conclude that the Mars is also inhabited like the earth. Symbolically we can illustrate analogy in the following manner :—If **B** resembles **A** with regard to the attributes **xyz** and if we know already that **A** possesses the attribute **p** then by analogy we can infer that **B** also possesses the attribute **p**. Illustrations

Carveth Read has defined Analogy as "a kind of probable proof based on the imperfect similarity (as the best that can be discovered) between the data of comparison and the subject of our inference." From this definition it is clear that Analogy establishes probable conclusion and cannot give us rational certainty. Hence we conclude that Analogy is no proof. It is a method of discovery as it suggests good hypotheses in order to be proved later on by the experimental methods. We also notice that Analogy is grounded on imperfect similarity and not on essential similarity which is grounded on causation. It is popularly believed that things which are similar in some respects are C. Read's definition.

also similar in others. This is a popular version of the Uniformity of Nature and Analogy is grounded on this popular principle. For this reason it sometimes establishes disastrous conclusions. When we find that two boys come from the same village, have the same age, same religion, same caste and height, read in the same class, and reside in the same hostel, and if one of them be found to be intelligent then by Analogy we can argue that the other is also intelligent. But we know that this argument is entirely fallacious because the points of similarity are superficial in nature and are not relevant to intelligence. Hence in applying Analogy we should not simply count the points of similarity but we should weigh them, i.e., we should see whether they are essential and are relevent to the subject matter of inference.

Analogy is grounded on a popular version of the uniformity of nature.

Bad analogy.

Analogy has been defined by Whately as the *resemblance of ratios or relations.* Aristotle defines it as the *equality of ratios*, analogical reasoning can be expressed mathematically in the form of the equality of ratios, i.e., in the form of proportion, e g., Health : Body : : Virtue : Soul In other words on account of this resemblance we can infer that just as health perfects the body so virtue also perfects the soul. Similarly Father : Family : : King : Subject. So by Analogy we can infer that just as the members of the family are morally bound to obey the commands of the father so the subjects are also morally bound to follow the commands of the king. The logical value of this sort of argument

Aristotle and Whately.

Value of their analogy.

is almost nothing as it is based upon inessential similarity and as it does not consider any causal relation between the objects that are related to one another in the form of proportion.

The value of analogy depends on the nature of similarity on which it is based.

2. **The Conditions on which the value or the strength of Analogy depends.** The Analogical argument is grounded on the resemblance between the data of comparison and the subject of our inference. So the value or the strength of Analogy depends necessarily on the nature of similarity on which it is grounded and the relevancy of these points of similarity to the subject matter of inference. The more these points of resemblance approach the causal basis the more becomes the value and strength of analogy. One's caste, religion, height, etc., have hardly any connection with his intelligence, hence it is bad analogy to argue that a person is intelligent because he has the height, caste, and religion of Sir Ashutosh. But land, water, and atmosphere are essentially connected with the existence of life, and so the analogical argument that the Mars is inhabited like the earth as it resembles the earth with regard to land, water, and atmosphere is an instance of good analogy. Hence in ascertaining the value or strength of analogy we should not simply *count* the points of resemblance but we should *weigh* them. When two objects differ fundamentally or when our knowledge about them is meagre it is idle to extend the truth detected in one of them to the other. Human body is fundamentally different from a rope and so

The value does not depend simply on the number of the points of similarity.

if we argue analogically that the human body will last longer if it be kept always dry like a rope then we shall commit a great blunder From what has been said above the following principles or conditions have been deduced for determining the value or strength of Analogy.

Conditions.

(i) *The greater the number and importance of the points of similarity the more is the value of the conclusion established by analogy.*

(ii) *The greater the number and importance of the points of difference the less is the value of the conclusion established by analogy.*

(iii) *The greater the number and importance of the unknown properties of the subject of our inference the less is the value of the conclusion established by analogy.*

All these conditions have been expressed by the following formula :—

$$\text{Strength of Analogy} = \frac{\text{Resemblance}}{\text{Difference} + \text{Unknown properties}}$$

In this connection we should remember that Analogy does not pretend to establish rational certainty and that it is not grounded on the law of causation.

Analogy and Induction.

3. **The Value of Analogy.** In Analogy we take into consideration only the quantity of likeness that one phenomenon bears to another irrespective of its importance and consequently we can get only probable truth by analogical argument, whereas in Induction we base our argument upon the

character and definiteness of the points of likeness found in the data of our inference and direct our attention to the inner essence of the data in question. It is for this reason that in Induction our argument goes beyond the domain of probability and establishes conclusions of which we are rationally certain. No causal relation is ascertained in Analogy and also no such importance is placed upon the character and definiteness of the points of likeness as in Induction,

Logical value of Analogy.

It is for this reason analogical argument is very shallow and uncertain. It is neither used in important deliberation nor in scientific research. It is also for this reason in Logic which is a science of truth Analogy has hardly got any value of its own. It rather misleads us from the path of truth and science, and prompts us to take a conclusion to be true when we ought to think it only probable. So as a mode of proof Analogy may be neglected.

Analogy is no proof.

Analogy is a great source of hypothesis.

But in another way Analogy has its use In Science and Logic. It helps us in getting at probable hypothesis which will explain a phenomenon under investigation. Rival hypotheses are also suggested by analogical argument. This is due to the fact that analogy is based on similarity. But here we may note that the value of Analogy as a suggestive force is Psychological. and not logical. From the standpoint of Psychology it is very easy for us to see that the value of analogy is very great as most of our arguments of every day life are based upon analogy. When a person runs away from a

water snake he argues by analogy. He takes for granted that things alike in some respects are alike in others and infers that the water snake is venomous. Similarly when a lump of chalk is presented to a child he puts it in his mouth arguing by analogy that it is white like a lump of sugar and so it must be sweet.

As a Method of discovery Analogy is highly useful.

Now as analogy suggests hypothesis and as with the help of hypothesis we make our discoveries so as a mode of discovery Analogy plays a very important part in Logic which as a science has to discover the laws of nature and to prove them. The mines of Australia and America, the volcanoes and petroleum mines all over the world have been discovered by analogical inference based upon the similarity of the land surface, craters, etc.

Great discoveries have been made by analogy.

Place of Analogy in Induction.

Induction cannot proceed a single step without hypothesis and Analogy does a great service to Induction by supplying us with hypothesis. The application of the experimental methods is possible when we are able to gather suitable facts in the light of good hypothesis. Hence Analogy by giving us good hypotheses enables us to apply the experimental methods. Therefore Analogy is very useful in Logic even though it is not a method of proof.

4. **Analogy and Induction.** In Induction we proceed from a number of particulars to a universal real proposition or a law of nature whereas in analogy we proceed from one individual object to another individual.

Induction establishes material truth. Analogy also

tries to establish material truth but the conclusion established by analogy is probable in nature whereas the conclusion arrived at by Induction is rationally certain and is reliable. This is on account of the fact that Induction is grounded on the Law of Causation while Analogy is grounded on imperfect similarity.

Like Induction Analogy is a form of mediate inference and is grounded on observation and in both of them we proceed from the known to the unknown. But the degree of carefulness required in Induction and the careful analysis of the circumstances in which a phenomenon under investigation occurs are not to be found in analogical argument.

How Analogy can be transformed into Induction.

But analogical argument can be very easily transformed into an inductive inference by showing that there is a causal relation between the points of similarity and the subject of our inference. The analogical argument that like **A**, **B** possesses **p** because it resembles **A** with respect to **x**, **y**, and **z** can be transformed into induction by showing that there is a causal connection between **x**, **y**, **z**, or some of them on the one hand and **p** on the other. Similarly if we can establish a causal connection between land, water, and atmosphere on the one hand and the existence of human beings on the other then at once the analogical argument that the Mars is inhabited like the earth as it resembles the earth with respect to land, water, and atmosphere will be converted into an inductive argument.

An Analogical argument supposes a generalisa-

Analogy involves implicit generalisation.

tion from a single instance without developing it or proving it by the experimental methods, and the analogical conclusion is really deduced from this implicit generalisation. The above mentioned argument really involves two arguments of which one is inductive in nature and the other is deductive. We first of all observe that the earth has land, water, and atmosphere and is inhabited. At once we make a hasty generalisation that all planets having land, water, and atmosphere are inhabited. Using this as the major premise and the proposition that the mars has land, water, and atmosphere as the minor premise we arrive at the conclusion that the mars is also inhabited. Thus analogy really involves within it both induction and deduction though it pretends to proceed from one particular to another particular. It should be noted here that the generalisation involved in analogy contains the further fallacy of co-existence viewed as causation.

Analogy involves both induction and deduction.

Fallacies involved in analogy.

5. **Analogy and Deduction.** Both of them are processes of mediate inference and both of them rest upon the principle that things alike in some respects are alike in others. But Deduction is based upon *perfect similarity* whereas Analogy is grounded on *imperfect similarity*. But there are also points of difference between them. In Deduction we pass from the universal to the particular i.e., from all to some, or from more general to a less general proposition, whereas in Analogy we pass from one particular to another particular. In

Deduction our aim is to establish *formal* consistency or truth whereas our aim in Analogy is *material* truth.

Here we may note that an analogical argument has a close resemblance to that form of deductive reasoning which we call Enthymeme of the first order in which the major premise of the syllogism is suppressed. Thus when we argue that brutes have understanding as they like men possess sense organs we surely proceed by analogy. But if this reasoning be clearly stated we find that it may take either of these two forms (i) All beings having understanding possess sense organs: the brutes possess sense organs: therefore the brutes possess understanding. This is surely fallacious as the middle term is not distributed. (ii) All beings possessing sense organs have understanding: the brutes are beings possessing sense organs; therefore the brutes have understanding. In this form the reasoning becomes formally correct. Analogy seems to suggest the second form of enthymeme rather that the first.

Analogy and Enthymeme of the first order.

Now in deductive reasoning we take for granted that the major premise is an established truth, whereas in Analogy we rush up to the major premise from one individual instance or from only a few instances. In the illustration mentioned above we start from our understanding and observe that we possess sense organs. From this we at once unduly take for granted that living beings possessing sense organs have understanding. Similarly

Analogy involves hasty generalisation and deduction.

in the analogical argument that the Mars is inhabitsd by people like ourselves we take for granted that all planets possessing land, water, and atmosphere are inhabited without caring to know whether it is a proposition thoroughly established. Thus Analogy involves hasty generalisation and deduction, and is not a new form of argument as it seems to be.

6. **Fallacy in Analogy.** ·When Analogy is based on flimsy or superficial points of similarity totally irrelevant to the subject matter of our inference then analogy becomes fallacious. Such an

Bad analogy.

analogy is called by the name bad analogy. As for instance the Head Pandit and the Head Master

Illustrations.

have 'head' in their names. Therefore for free studentship we should apply to the head pandit just as we apply to the head master. Similarly we advance bad analogy when argue that we must keep our body always dry and must not take any bath because a rope which is kept always dry lasts longer than a rope which is made alternately dry and cold. Similarly it is bad analogy to say that after taking a very hot both we should take a very cold bath because iron becomes converted into steel when making it extremely hot we give it an extremely cold bath. Similarly we have bad analogy when we argue that nations, communities, races, and culture pass through the three stages of growth, vigour, and decay just like an individual. Again the increased size of the metropolis is a disease because the increased size of the heart is a

disease and every one knows that the metropolis is the heart of the kingdom. This is also a bad analogy because the points of difference between heart and the metropolis are too many and fundamental. We have bad analogy whenever there is fundamental difference between the data of comparison and the subject of our inference. It is also a fallacy to establish an assertory proposition by analogy, because such an argument establishes only probable conclusions.

How an analogy becomes bad.

7. Exercises.

1. Define and illustrate Analogy. What is the evidentiary value of such a reasoning ?

2. Is Analogy different from induction ? and deduction or does it involve both of them ?

3. Show how an analogical argument can be converted into an inductive argument.

4. Show the resemblance between an analogical argument and an Enthymeme of the first order.

5. Is Analogy a method of proof or a method of discovery ?

6. Show how we are to measure the strength of an analogical argument.

7. Explain the relation between (i) Analogy and Induction, and (ii) Analogy and Deduction.

8. How and why do we reason by Analogy ?

9. What conditions should an analogical argument fulfil in order to be convincing ? Discuss by means of examples. How does it fall short of

CHAPTER IX

The Deductive Methods.

1. The Nature of the Deductive Method. The nature of the Deductive method can be gathered from the *Dictum de omni et nullo* which lays down the fundamental principle of deduction. It means "Whatever is predicated (affirmatively or negatively) of a class distributed, in which term another is given as (partly or wholly) included, may be predicated in like manner (part or all) of the latter term". From this it is clear that the deductive method requires some general truth either given to be true or assumed or established fully by induction. The conclusion of a deductive reasoning remains doubtful if the general proposition from which we start is only given to be true or is only assumed to be true. In order to be conclusive the general proposition must be established by induction or must be axiomatic for it is on the authority of this proposition our deductive conclusion is mainly based. When we simply extend a previous induction to a new instance the process will be simple, e.g., when we extend the inductive truth,—All men are mortal to the case of Ram by showing that Ram is a man, we follow the simple deductive method. But when we combine two or more previous inductions in order to deduce some

Two kinds of Deduction :—

(a) Simple

(b) Complex.

complex phenomena or relations our deduction becomes complex, e.g., our explanation of the rise of water in the common pump.

Thus we have two kinds of deductive methods, viz., **simple** and **complex**. We have simple deduction in the syllogistic reasoning and also in the verification of hypothesis. In the syllogistic form of simple deduction our aim is to establish formal truth and not material truth. In the Complex Deductive Method on the other hand we have a number of laws and deduction from these laws together with the comparison of this deduced truth with the facts and phenomena occurring in nature. The aim of this Complex Deductive Method is the establishment of material truth and for this reason observation plays an important part in it. But in one of the Complex deductive methods observation is considered to be unnecessary while in the remaining two we establish the calculated result by observation or the result of observation is established by deduction. Thus in one of these methods observation comes at the very beginning while in the other it comes at the end. But in the last complex deductive method observation is thought to be unnecessary. In the Inductive Logic we are concerned with these Complex Deductive Methods. These Methods are also called **Deduction in Induction.**

The place of observation in the Complex Deductive Method.

2. **Where are these Methods applicable?** In order to establish a law of caustion or a law of nature we are are required to apply the

Difficulty in the application of Experimental Methods.

Experimental Methods. These methods require the analysis of the phenomenon under investigation and the circumstances in the midst of which it occurs into their elementary factors. Besides the instances of this phenomenon should agree either in only one point or differ only in one point. But in practical investigation we generally come across such complex phenomena that we cannot analyse them into their elementary factors, and the instances of these phenomena are found to agree in more points than one and differ in more points than one. So to these phenomena we cannot strictly apply the Experimental Methods. Besides we find frequently homogeneous and heteropathic intermixture of effects and also the plurality of causes which cannot be removed by the specialisation of the effect and the generalisation of the causes. For this reason the application of the experimental methods becomes almost impossible in our practical investigation. But the experimental methods should not be rejected for this reason. They represent in fact the ideal methods of inductive reasoning to which we should try to approach though we fail to rise up to their standard.

The Deductive methods are applied when there is homogeneous intermixture.

Now the Complex deductive methods are ordinarily applied when there is homogeneous intermixture of effects. These are also applied to cases where there is the possibility of plurality of causes. Some logicians maintain that the experimental methods are applicable when there is a hetero-

pathic intermixture of effects because such an intermixture changes the objects or phenomena qualitatively. But this view is not correct because the heteropathic intermixture represents a higher form of intermixture and if the experimental methods be not applicable to the homogeneous intermixture of effects, it follwos necessarily that these are not applicable to the higher form of intermixture as represented by the heteropathic intermixture.

Are they applicable to heteropathic intermixture ?

It should be noted in this connection that the word 'induction' was originally used in the sense of simple enumerative induction which is based on uncontradicted experience and not on the law of causation. For a long time such an argument was not treated as a logical argument for its evidentiary value is really very small. But now-a-days we do not mean by induction simple 'enumerative induction but a generalisation grounded on the law of causation and the uniformity of nature, and the experimental methods deduced from them. Hence the modern inductive method contains within it a considerable amount of deductive element. But in the original induction no deductive element was present. The methods known as the complex deductive method or Deduction in Induction tell us that the most reliable conclusion can be arrived at when the results of induction are verified by deduction or the results of deduction are grounded on the conclusion of induction. Therefore in our practical investigation we should apply both deduction and induction

Distinction between the old and modern induction.

in order to establish a reliable conclusion. But as a matter of fact this is what is done in the modern inductive investigation as required by the experimental methods. In induction we generally form a hypothesis and deduce conclusions from this hypothesis, and then compare these conclusions with the facts and phenomena occurring in nature. This comparison is called by the name verification which is a deductive process. We are also required to prove the hypothesis with the help of the experimental methods, i.e., we are required to show whether the hypothesis in question can be deduced from these methods. Hence the Complex deductive methods do not give us any new message and do not tell us anything which is not given by the experimental methods and the method of hypothesis. Hence the efficacy of the complex deductive methods comes in when we use induction in the sense of simple enumerative induction.

The modern inductive method and the hypothetical method comprehend the complex deductive methods.

3. **Conditions of Deductive Methods.** The Deductive method contains within it three steps :—

(i). *The Ascertainment of premises by induction or observation.* The major premise is to be established by induction and the minor premise by observation, experiment or induction.

(ii) *Ratiocination* or deduction proper by which we combine the premises so as to ascertain what conclusion we can draw from their co-operation, e.g., from the law of gravitation, the atmospheric pressure, the distribution of forces in a

liquid, and the laws of friction we conclude deductively how far water will rise in a common pump.

(iii). *Verification*, i.e., the comparison of our conclusion with the existing facts of nature in order to determine finally whether there is any flaw in our premises or deduction. When there is some error in the process of deduction we can correct it by a critical examination of the process. But when there is error in the premises we should see whether any relevant premise has been left out or some irrelevant ones have been included. There might be also some error in the laws used as the premises.

Hence the application of the deductive methods depends on the following conditions :—

(a) Certain agents or causes producing the complex phenomenon to be explained by the deductive methods.

(b) The law of operation of these agents already established by induction, either scientific or simple enumerative.

(c) The circumstances in the midst of which these agents operate.

(d) Calculation, ratiocination, computation, or deduction of a complex result from the operating agents and circumstances and their laws.

(d) Comparison of this calculated result with the facts and phenomena occurring in nature, i. e., verification.

If any one of the factors be wanting the complex deductive method cannot be applied accurately.

All the factors are not equally needed in all the methods.

But observation which is one of the most important factors is not thought to be necessary in one of the complex deductive methods. But there is no harm if we verify our calculated results with the help of observation even in that method. In one of these deductive methods the agents are not known or are partly known. But undoubtedly these agents are in the background even when they are not known because without them the complex phenomenon to be explained by the deductive methods cannot take place. Therefore whether known or unknown, used or unused these factors are there whenever we consider complex phenomena by the deductive methods. All these factors or conditions have been brought under three heads, viz., (1) agents together with their laws, (2) computation, (3) and verification.

4. Kinds of the Complex Deductive Method.

Kinds of Deduction in Induction:

Three complex deductive methods:

There are three kinds of the complex deductive method, viz., (1) **The Direct or the Physical Method**, which is widely used in the physical sciences and in higher mathematics; (2) **The inverse or the Historical** Method which is widely used in History, Sociology, Politics, and even in the physical sciences where quantitative relation is the main subject matter of investigation; (3) The **Geometrical Method** or the Absolute or the Abstract Method which is used in higher mathematics and also in metaphysics, politics, and sociology. These methods have no rigid scopes of their own and

they are freely used in those spheres for which they were not originally meant.

5. **The Direct or the Physical Method.**

This method consists in deducing a complex conclusion from a number of agents and laws already established by induction and then establishing this deduced conclusion by means of verification, i. e., by comparing the calculated result with the facts and phenomena occurring in nature. If the calculated result be in harmony with the facts and phenomena occurring in nature then the complex phenomenon under investigation is said to be explained by the agents and laws from which the calculated result has been deduced. Thus this method contains the following factors :– (1) the agents and laws already established. In some cases when established laws are not available some hypotheses as to the agents and laws are formed. (2) Calculation or deduction, and (3) Verification. Here the result of deduction is established by verification, and deduction is applied directly at the very beginning. For this reason this method is called the Direct method. It is called the Physical Method because it is widely used in the physical sciences and in higher mathematics.

Definition.

Analysis of the direct method.

Why is it called direct?

Illustrations :—An ordinary pump by which water is supplied in a particular town is subject to the operation of the following agents and circumstances :—(i) the pressure of the atmosphere, (ii) gravity, (iii) friction, (iv) the law that a liquid keeps the same level, and (v) the

law of the distribution of forces in a liquid. From these agents and laws we can calculate mathematically how far water will rise in the pump. Suppose we calculate that at Monghyr water will rise up to 28 feet and if we actually find by observation that water rises exactly up to that height and no further then our explanation as to the rise of water in the common pump at Monghyr is correct. Similarly when a cannon is fired we may try to explain how far the ball will go. Now the cannon ball is subject to the following agents :— (i) forces generated by the explosion of gun powder in a closed chamber, (ii) gravity, and (ii) the resistance of the air. If we know the force generated by the explosion, the effect of gravity on the ball and the actual resistance of the air then we can mathematically calculate at what distance the cannon ball will hit the ground and to what height it will reach. If the calculated distance and the height be found to be in agreement with the actual distance travelled and the actual height reached by the cannon ball then our explanation should be treated as correct.

Where can this method be applied?

This method can be applied only when the operating agents and their laws are knwon, e.g., if we happen to be ignorant of the force generated by the explosion of gun powder it will not be possible for us to apply this method.

Definition.

6. The Inverse or the Historical Method.

This method consists in observing first of all a number of facts and than establishing a law by

simple enumerative induction, and lastly proving this law by deducing it either from some already established induction or from some axiomatic principles. Thus the method contains the following factors :-

Analysis of this method.

(i) observation of particular facts,

(ii) establishment of a law by simple enumerative induction, and

(iii) deduction of this law from some already established induction or some axiomatic principles.

This method is called the Inverse Method because we first of all start with observation and establish a law by induction and again establish this inductive conclusion by deduction. Thus the result of induction is proved by deduction, and so this method is called the inverse method as opposed to the direct method where the result of deduction is proved by observation an important factor of induction. The inverse method is called the Historical method because it is widely used in the historical sciences, e. g, history, economics, politics and sociology. It is also widely used in the positive sciences and is identical with the modern *hypothetical method*. It is generally applied in those cases where the operating agents or conditions are unknown or partly known.

Why is it called the inverse method?

Why is it called the Historical method?

The hypothetical method.

Illustrations. (1) We find that the peasant proprietors of the different countries of the world are very economical in their habits. We examine the peasant proprietors of Australia, America, Africa, Italy, Russia, and India, and find that they are all economical in their habits. Thus we establish by

simple enumerative induction that all peasant proprietors are economical in their habits. But this simple enumerative induction cannot be reliable as it gives us probable conclusion. So in order to be sure we try to deduce it from some already established induction or from some axiomatic principle. We find in economics the law that money earned by one's own physical labour are always spent very economically and carefully, The peasant proprietors also earn money by their own physical labour. Therefore we deduce the empirical law already established by us from this axiomatic principle of Economics and then and then only we become sure of our conclusion.

(2) We observe a number of instances in which the eastern wind blows over Belgium and we find that in every case people fall ill whenever this wind blows.. Therefore by simple enumerative induction we draw the conclusion that the eastern wind is injurious to the people of Belgium. But we cannot rely on it as it has been established by simple enumerative induction. So it requires further proof. We find by analysis and closer examination that the eastern wind of Belgium blows over the whole of Siberia, Russia, Northern Germany, and as such it carries along with it all the foul gasses of this vast land region. In other words it is a ground current and contains poisonous gasses. It has been already established by the positive sciences that the poisonous air is injurious to our health. From this law we now stabliseh

by deduction that the eastern wind that blows over Belgium must be injurious to the people of Belgium.

7. The Geometrical Method, the Absolute or the Abstract Method

This method consists in deducing a complex conclusion from a number of axiomatic principles. In it there is no necessity for verification because the premises are the axiomatic principles and the process of reasoning is deductive. Hence this method establishes necessary truths while the other methods establish experimental truth or assertory truth. When the initial velocity and acceleration of a rigid body is known, then by this method we can calculate the greatest height that this body will reach. Here we feel no necessity for verification. Similarly in politics when we deduce a conclusion from the fundamental rights of man we require no verification, e.g, when we conclude that the flood stricken people must be saved by the Government without any delay because every one has the right to live and human lives should not be allowed to be destroyed, we apply this geometrical method. Similarly in Economics many complex conclusions are deduced from the fundamental laws of demand and supply and we repuire no verification for them. This method is called the Geometrical method as it is widely used in the geometrical and mathematical sciences where no verification is necessary, and yet the conclusion is absolutely true. This method seems to be identical with the ordinary syllogistic method but it is not so because

Definition.

Verification is not necessary. Why ?

Where is this method applicable ?

Distinctio between the Geometrical method and the Syllogistic Method.

this method establishes material truth and in it a conclusion is deduced from a number of axiomatic principles.

Does Induction precede Deduction ?

8. **Place of the Deductive Method.** This is identical with the problem whether induction precedes deduction or deduction precedes induction. We have already found in Ch. 1 Sec. 5 that there is a relation of interdependence between deduction and induction and so it is not proper for us to say that one of them precedes the other. We have seen already that the modern process of induction involves a considerable amount of deductive element and the validity of the inductive conclusion depends on this deductive element. Hence though it appears that induction precedes deduction yet scientifically and actually deduction precedes induction.

These methods explain the complex phenomena.

9. **Use or Function of the Deductive Method.** The fundamental function of the Deductive Method is to explain the facts and phenomena which are too complicated to be explained by the experimental methods. These methods can help us very little when we have composition of causes and the intermixture of effects. It is by the complex deductive methods that we generally explain such phenomena.

Deduction supplies the proof-side of Induction.

The second use of deduction is to prove an already established induction beyond any doubt by extending it to those facts and phenomena which were not previously examined by us. The greatest function of deduction is to supply the

proof portion of induction which makes inductive reasoning reliable.

Induction and deduction being interdependent we must supplement the one by the other if we want to establish a conclusion beyond any dispute. To depend upon the empirical method like induction (simple enumerative induction) alone is precarious while to depend on a purely theoretical method like deduction is no less uncertain, as without the help of induction we cannot be sure of the premises of deduction. Thus for the establishment of concrete truths we must combine both the processes of deduction and induction.

Induction and deduction are supplementary.

10. **Inductive and Deductive Sciences.** Induction and Deduction being interdependent it is hardly possible to classify sciences logically into inductive and deductive sciences. Moreover a science which is inductive at the first stage becomes deductive when it becomes developed to a certain extent. From this it is clear that induction and deduction mark the two stages of scientific development. Therefore we can classify sciences as inductive and deductive according to the predominance of the inductive or the deductive method of reasoning. Also the sciences in which we apply the physical or the direct deductive method are called deductive and those in which the historical or the inverse method is applied are called inductive. The sciences which are based upon observation or experiment or both such as Geology, Botany, Physics, Chemistry, History may be called inductive, while

Difficulty in classifying sciences as inductive and deductive.

those that are based on theoretical calculation or explanation such as Mathematics, Mechanics, Economics, Sociology are called deductive. The aspect of fact generally predominates when the science is in its elementary siage, whereas the aspect of explanation predominates as it becomes developed, i. e., when some laws and principles have been established by the inductive process.

The ultimate goal of sceince.

11 **The Actual Method of Scientific Progress.** The aim of science is to establish the truth that the facts and phenomena of this universe are all correlated with one another and are governed by one pervading law or principle or a system of correlated laws.

The means adopted for its realisation.

Now in order to achieve this aim the scientists divide the world system into several convenient departments and confine their investigation to these departments separately, otherwise the immensity of the world would have baffled any attempt at explanation.

The stage of facts and generalisation or induction..

It is after a considerable amount of progress that the scientists determine the relation that exists between the truths found in the different departments of the universe as well as between the departments themselves and thus arrive at a scientific conception of the world system as a whole.

The stage of verification, explanation or deduction.

Now in each of these departments of nature the scientists first of all gather facts by observation and experiment, determine their nature, frame hypotheses as to their causes and modes of operation and draw empirical generalisations out of these facts

The final correction of the different sciences.

Then they establish these laws by means of extensive verification and the experimental

methods. These laws again are generalised into higher and higher laws and lastly these laws are correlated into a system. The next step is the correlation of one system of laws with other system of laws. This is more correctly the business of the philosophers and not of the scientists. In this way the scientists arrive at an idea of the world as a system of laws. In all these stages the scientists move from facts to principles or laws and from lower principles or laws to higher ones ; So the progress is inductive. But along with this we have the stage of explanation which is deductive in nature. Here by observation and experiment we show that the new facts and phenomena observed by us can be deduced from the already established known truths and laws. This may also be called the stage of verification as we see here whether the new facts prove our inductive conclusions.

Thus we see that the true method of scientific progress is the logical enquiry which involves both deduction and induction. But we should note that at the initial stage science is mainly inductive in method but with its advancement it becomes more and more deductive as new problems and facts are deduced from the laws established beforehand.

We should also note that most of the facts generalised in science are highly complicated in nature and so the pure inductive methods can hardly be applied to them. In all such cases the mixed method which combines both induction and deduction is generally applied. Besides some universal

laws are supposed in all our investigation. So it is wrong to hold that at one particular stage our method is purely inductive or purely deductive. Hence the proposition that in scientific progress we proceed from induction to deduction is to be taken with some reservation. It is on account of the predominance of induction that the initial stage of a science is called inductive while on account of the predominance of deduction that the advanced stage of a science is called deductive.

At every stage science uses both induction and deduction, so it is not fully correct to say that science proceeds from induction to deduction.

12. Exercises.

1. Explain and illustrate the various forms of the Complex Deductive Methods. Where are they applicable?

2. Explain the nature of the Deductive Methods. Distinguish between the Complex and the Simple Deductive Methods.

3. On what conditions does the application of the Complex Methods depend? What part does verification play in all these methods?

4. Distinguish between the Historical and the Physical Method. Why are they so called? Where are they applicable?

5. Explain and illustrate the Inverse Method. Where is it applicable? Why is it so called? Is it different from the Hypothetical Method?

6. Explain and illustrate the Geometrical Method. Why does it neglect verification? How

does it differ from the ordinary syllogistic reasoning ?

7. Explain clearly the function of the Deductive Methods.

8. Give a critical estimate of the division of sciences into Deductive and Inductive.

8. Give a critical estimate of the method gradually followed by the pcsitive sciences in achieving their goal.

10 Analyse the Method known as Deduction in Induction Give some examples of the application of this method. Show how this method is to be distinguished from syllogism.

11. Explain what you mean by the Historical Method. Show how it differs from the Direct Deductive Method.

12. What is meant by Deductive and what by an Inductive science ? State the principal Deductive and the principal Inductive sciences explaining in the case of each of these sciences, why it is called Deductive or Inductive.

13. When is the Deductive Method employed in Inductive investigation ? Distinguish between the Direct and the Inverse forms of this Method.

14. Explain the Deductive Method in Induction. If a correct deduction from given inductions does not agree with fccts, what may be the possible source of error ?

CHAPTER X

Chance and the Doctrine of Probability.

1. **Chance.** When a student commits a mistake in spelling an ordinary word he says, "Oh! I did it by chance". He knew the spelling, yet he spelt it in the wrong way. He cannot explain how he did it, so he says he did it by chance. Similar is the case with chance witnesses e. g. P says that he was present when A paid Rs. 1000 to B. He was not called to the place of payment by anyone but he happened to be there at that particular moment—he might have been at any other place at that moment. So he says that he was there by chance.

Chance mistake.

Chance witness

Now this chance was once supposed to be "a distinct power in the world disturbing the regularity of nature." But this view of chance is not accepted nowadays. Everything is now believed to be produced by some appropriate cause whether known or unknown, and chance is identified with ignorance. So the popular view of chance is contradicted by the law of causation. When our knowledge is complete all chance disappears. Thus when we fail to explain a thing we say that it is due to chance. Chance has been defined by Mill as a coincidence giving no ground to infer uniformity, for it is only by causal connection that the

Popular meaning of chance.

Scientific meaning of chance.

happening of an event can be uniform. So in Logic chance is used in the sense of a coincidence to which our knowledge is not far advanced as to assign a cause. (C. Read).

2. **Probability**. When a student appears at an examination we cannot say with certainty whether he will pass or not. There is the possibility of his failing in the examination. Therefore we cannot be sure of his success. But in those cases where we add two numbers we are quite sure that the result will be always the same unless we commit a mistake. Similarly when we clap our hands we are always sure that sound will be produced. In these cases we have not the slightest doubt as to the happening of the result. Now when our belief is not of the highest degree of certainty our expectation is said to be probable. As long as an event is not impossible and our belief as to its happening is less than certainty we *scientifically* call it probable.

Illustration of probable event.

Significance of probable event.

But from the *popular* point of view an event is called probable when it is more likely than not to happen. Therefore rainfall in May in Bihar is not probable popularly, because it seldom occurs in this month in Bihar. But scientifically it is probable because rainfall in this month is not impossible.

Two senses of probability :—

a. Popular and

b. Scientific.

Probability may be defined from the standpoint of causality. When we fail to determine the cause of a thing we take into consideration the frequency of the happening of the thing in the midst of the

Probability defined from the standpoint of causality.

circumstances in which it occurs. Now probability is our expectation based upon the average frequency of the happening of an event. As the cause of the event has not been determined we cannot be reasonably certain of our expectation. Therefore we call the happening of this event only probable. (C. Read).

Chance stands for ignorance. Probability for approximate knowledge, and Induction for certainty.

3. **Chance and Probability distinguished.** An event or coincidence whose cause cannot be ascertained is said to be due to chance. Whereas an event or coincidence is called probable when we expect its happening on the ground of the average frequency of the occurrence. of the event or coincidence. Thus probability is based on the average occurrence of chance events and chance coincidences. Hence probability gives us approximate generalisations which in course of time makes room for scientific generalisations. Thus chance stands for ignorance, probability for approximate knowledge and induction for scientific knowledge, i. e., rational certainty. Thus probability indicates a step in advance from chance. Besides chance is generally used in connection with the coincidence of events, while probability is used in connection with the happening of individual things and phenomena.

Probability is represented by a fraction less than **1** and greater than **0.**

4. **Mathematical representation of Probability.** Probability is mathematically represented by a fraction which is greater than *zero* and less than *one*, while certainty is represented by *one* or *unity* and impossibility is indicated by *zero*.

The denominator of the fraction which represents probability stands for the number of the happening of the circumstances in which the event occurs, whereas the numerator stands for the number of the happening of the event in those circumstances. When we calculate the happening of an event in a particular manner the denominator of the fraction will represent the number of times the event occurs and the numerator will represent the number of times the event occurs in that particular manner. Suppose when in throwing a dice the ace turns up in the average once in six; we mathematically represent the probability of the ace turning up in each occasion by $\frac{1}{6}$ Here 6 represents the number of times the dice is thrown and 1 represents the number of times the ace turns up during these six times *in the average*. Similarly when observing a large number of matriculates we find that 5 out of 100 matriculates pass the B.A. examination we represent mathematically the probability of a matriculate passing that examination by $\frac{5}{100}$, i.e., by $\frac{1}{20}$ In language we express this fraction by saying that the probability of a matriculate passing the B.A. examination is one to nineteen (1 : 19) while the probability of his failing is nineteen to one (19 : 1) or the odds against his passing the B.A. Examination is 19 : 1. We may express the same by saying that the probability is 1 to 19 *for* his passing that examination or *against* his failing in it. Similarly when we say that the probability of a Bengali living

Significance of the numerator and the denominator.

Examples.

Representation of probability by a ratio.

up to the age of sixty is $\frac{1}{30}$ what we mean by this fraction is that a large number of Bengalees have been examined and it has been found that in the average out of thirty Bengalees one lives up to that age and so the probability of a Bengali boy living up to that age is very small.

Jevons says that probability is grounded on belief—the subjective ground of probability.

5. **The Grounds of Probability.** Logicians are not agreed as to the ground of probability. According to **Jevons** probability is grounded on belief and has nothing to do with the existing state of facts and circumstances. This is the **subjective view** of probability. If we put in a box a number of balls of which one is red and the rest white and then try to draw out the red ball we shall find that the probability of the red ball coming out will greatly vary according to the state of our mind. The more the balls are drawn out the more becomes the probability of the red ball coming out. It goes on actually increasing like this: $\frac{1}{100}, \frac{1}{99}, \frac{1}{98}, \frac{1}{97}, \frac{1}{96}, \frac{1}{95}$ etc. But to us it will be quite different. After being unsuccessful a few times we shall say, "Oh! it won't come out," and a little while after we shall hold that it will be the last one. This becomes clear to those who purchase a ticket in the lottery and remains present at the time of the drawings. This is also clear to persons going to a race and backing a horse. So probability varies according to our belief and not with the actual state of things and circumstances.

Illustrations from lottery and race.

For another reason also we may hold that probability is purely subjective. According to the law of

causation every event takes place on account of some cause whether known or unknown. Hence there is no room for any chance or probability in nature. Probability, therefore, rests only on our ignorance which is subjective, and it is eliminated when this ignorance is removed.

Fresh reasoning for grounding probability on belief.

Carveth Read has objected to the view of Jevons on the ground that if probability be based on belief which varies from man to man and even in the same man from time to time it will hardly have any connexion with inductive logic which aims at material truth. Secondly he says that belief cannot be satisfactorily measured whereas we are required to ascertain the degree of probability in our inductive investigations. Thirdly he points out that probability will have hardly any reality in it if we base it on belief, pure and simple, because belief does not always correspond to the state of facts and circumstances.

Criticism of the subjective view.

According to **Carveth Read** and **Bain**, Probability like induction rests on experience and uniformity of nature or more correctly on statistics which is a record of facts and the law of average deduced from this record. Thus probability is an expectation based on the average frequency of the happening of facts. So Bain holds that probability is connected with a state of mind as well as with the nature of the objective facts and phenomena. When we say that a thing is probable we mean that objectively in our previous experience we have found that in some cases it happened and in some others

Probability is based on experience and the law of average.

Bain's subjective-objective view of probability.

it did not, so that subjectively we have in our mind a mixture of belief and doubt as to its happening in this particular case. Hence this view may be said to be the mixed view or the **subjective-objective** view.

Probability is based wholly on statistics—the objective view.

The third view on the subject is the objective view. According to it Probability has nothing to do with belief. It rests upone xperience, pure and simple, and the law of average formed out of statistics which records the facts of our experience. "Where statistical evidence is obtainable no one dreams of estimating probability by the quantity of his belief. This is manifest from the insurance offices which prepare elaborate statistics of death, fire, shipwreck, etc., and regulate their rates accordingly, and never take into consideration the quantity of belief they personally entertain." Here also we find that probability is a kind of calculation or inference which is a mental process. Hence this view is identical with the view of Bain and Carveth Read. Besides knowledge implies belief and so probability which gives us approximate knowledge cannot be separated from belief.

Criticism.

Induction is grounded on probability.

6. **Probability and Induction.** Some logicians such as Jevons and his school are of opinion that all knowledge and inference are probable. According to them even the rising of the sun in the morning is a probable truth and so is the mortality of man. Inductive truth being based upon inference is of probable nature. Jevons maintains that induction is based on probability on two

grounds, viz., (1) Nature is so vast, subtle and complex that it is impossible for us to know any thing or event fully and completely, and (2) there is no certainty that the laws and conditions of the universe (e.g., the law of the uniformity of nature) will remain always the same.

This view is partially correct. We know that there are two degrees of certainty, viz., (i) absolute certainty and (ii) rational certainty. From the standpoint of absolute certainty Jevons's view is tenable and human knowledge is probable. But from the standpoint of rational certainty we find that there are some relations which happen always. About these we are rationally certain. But there are also some relations which happen in some cases but fail to happen in some other cases. Hence our expectation of the happening of such a relation is said to be probable. It is improper to express rational certainty and probable expectation by the same term.

Mill holds that Probability is based on experience and approximate generalisation — a form of Induction.

Having this second kind of certainty in view Mill holds that probable inference is based on experience. There are many complex facts and phenomena whose antecedents and conditions cannot be wholly ascertained accurately. And we know also that the same effect can be produced by different causes. Now when we say that an inference is probable we mean that it is not grounded on any known causal relation and so the antecedent conditions of the subject matter of inference have not been discovered. The conclusions that there

will be rain and storm in Bengal on the last day of the Bengali year, that the number of deaths from suicide is constant and that every year there will be a certain number of unaddressed letters in the post office are all probable. But all these inferences are not the outcome of whimsical guesses but are based upon facts experienced and sometimes arranged in the form of statistics.

Inductive calculation compared with probable calculation.

Induction, we have found, is based upon causal relation and the experimental methods, whereas probability is based on the average frequency of occurrence. Inductive inference holds good in all the instances while probable inference holds good in the average number of instances and not in the case of an individual instance. In Induction the conditions are fully known while in probability the conditions are either unknown or partly known. But Probability like induction is based on observation and generalisation (approximate).

How to find the average.

7. **The Average and the Personal equation.** Suppose that the height of the students of a college varies from 3ft. 4 inches to 6 ft. 2 inches. Now if there be five hundred boys in the college, in finding out the average height of the students of that college we must add together the height of all the five hundred boys and divide the result by the number of the boys, i.e., five hundred. The result found out by this division will be the average height of the students of that college. We shall find by observation that most of the students of that college will be about that average height and the

instances in which the height will fall far below the average or far exceed the average will be rare. Those instances in which the height will be considerably less or more than the average are called **deviations** or **errors.** This average can be made the basis of our inference. Probable calculation is grounded on this average.

Significance of error.

By **Personal equation** we mean that every individual rational being has got his peculiar personality and as such has a tendency to distort the sense presentations, i.e., to view things in a way slightly different from what they are themselves. So in order to find out the personal equation of a man we are to find out his average deviation from the normal. The term personal equation is generally used in connection with experiment and astronomical observation. Every observer owing to his peculiar sense organs, height and position, not to speak of his mental complex is liable to a little wrong and this error must be corrected in order to get the right result. This personal equation is allowed for in scientific observation and experiment.

Meaning of Personal equation.

From the above it is clear that our personal equation introduces error in our observation and experiment and so in our calculation and inference, and thereby reduces all inferential truths based on experience to probable truths. When we talk of personal equation our standard of accuracy is very high. But in carrying on our life and in managing our everyday problems we do not require such a high degree of accuracy.

Effect of personal equation.

Probable calculation holds good in the average number of cases and not in any individual case.

8. **Probability and Average.** In probable reasoning we should always bear in mind that our inference holds good not in any and every case but only in the average number of cases, In determining whether our inference will hold good with regard to the individual case we should carefully see that this case is subject to only the general conditions governing the class to which it belongs and not to any other special condition. The likelihood of a probable inference being true in a particular case is very small on account of the reason (i)that probability is based on the average and (ii) that an individual instance always deviates from the normal or the general characteristics of the class. This deviation from the normal is called the personal equation.

Causal and Casual phenomena distinguished.

Chance is eliminated when the causal basis is detected.

9. **Elimination of Chance.** Chance we have seen stands for our ignorance of the causal basis of a phenomenon. A phenomenon is said to be *causal* when its cause is known and when its happening can be expected beforehand. Whereas a phenomenon is said to be *casual* when its causal basis cannot be known and so its happening cannot be expected beforehand. Therefore chance is eliminated when the cause is found out and we are able to predict reasonably the happening of a phenomenon.

Chance comes in when there is a plurality of causes capable of producing a phenomenon. If **A**, **B**, **C**, and **D** are separately and independently capable of producing **x**, we have a plurality of causes. In such cases we try to remove this plurality of causes

by the specialisation of the effect or the generalisation of the causes. When these two processes are not possible we apply the doctrine of chance. In this case we are confronted with propositions like these :—**A** may produce **x** ; **B** may produce **x** ; **C** may produce **x** : and **D** may produce **x**. But each of these "*mays*" has not the same significance and force. By applying the doctrine of chance we measure the value of these *mays*. When the value of these *mays* are determined chance is eliminated to a certain extent. But great difficulty arises when we come across the concurrence of phenomena, the happening of which cannot be expected on account of our ignorance of the causal basis. All events and concurrence of events are due to proper causes, yet on account of our imperfection we cannot find out the causes of most of the events and the concurrence of phenomena that happen in nature. So a distinction is made between *causal* and *casual* phenomena with a view to distinguish events whose causes can be ascertained by further investigation from those events whose causes cannot possibly be ascertained by further investigation. If the events are found to concur more frequently than they are expected to concur according to the rules of probable calculation then we should infer that the concurrence is *causal* and further investigation may lead to the discovery of the causal basis of the concurrence. But if the events do not happen more frequently than they are expected to concur according to the rules for the calculation of chance then we

The plurality of causes gives rise to chance. So chance is eliminated when the plurality of causes is removed.

Probability ascertains the value of 'may'.

How to remove chance from chance coincidence.

should infer that the concurrence is *casual* and further investigation will not lead to the discovery of the causal basis. All these have been embodied in the following rule which is commonly called the **rule for the elimination of chance :—**

"Consider the positive frequency of the phenomena themselves separately, and how great frequency of coincidence must follow from that, supposing that there is neither connection nor repugnance. If there is a greater frequency, there is a causal connection, if a less, repugnance."

If we find that A and B concur and fail to ascertain the reason why they do concur we say that they concur by chance. Now in order to ascertain whether this concurrence is really casual or causal, i.e., in order to eliminate chance we should observe first of all as many instances of A and B as possible. If the separate probability of A is 3/11 and that of B is 4/7, then if A and B be supposed to have neither connection nor repugnance the probability of their concurrence will be $3/11 \times 4/7 = 12/77$. Now if by observation we find that A and B actually concur more than 12 times out of every 77 times then we must infer that the concurrence is *causal* and not *casual*; and if we find that they concur less than 12 times out of every 77 times we should infer that there is repugnance between them. But it should be noticed that even in such cases no definite inference as to the happening of the concurrence can be made and the concurrence even after the appli cation of the rule for the elimination of chance

Criticism of the rule for the elimination of chance.

remains a chance concurrence. Hence the rule is hardly useful as a rule for getting rid of chance altogether. It is also misleading.

10. **Rules for the calculation of Chance or Rules for the estimation of Probability.** These rules seem to be very simple and also seem to lead to mathematical certainty. But actually they are neither. The problems relating to the calculation of chances that are set in the examination held by the institute of actuaries are bewildering to those who have not studied higher mathematics. By applying these rules we can never attain mathematical certainty. These rules have been arrived at not by mathematical calculation but by empirical generalisation. These rules also cannot be applied when extensive observation have not been made and elaborate statistics are not available. The conclusions arrived at by the application of these rules do not hold good in the individual cases but in the average number of cases.

Rules for the calculation of chance.

The following are the rules for the calculation of chance or the estimation of probability :—

Probability of the concurrence of two independent events.

(*1*) *The probability of the concurrence of two independent events is the product of their separate probabilities.* Suppose the probability of the occurrence of A is $\frac{5}{12}$ and that of B is $\frac{9}{10}$ then the probability of their concurrence is $\frac{5}{12} \times \frac{9}{10} = \frac{3}{8}$ or 3 : 5 when there is neither connection nor repugnance between A and B. Suppose the probability of a graduate becoming a deputy magistrate is $\frac{1}{10}$ and the probability of a graduate becoming a poet is $\frac{1}{25}$.

Therefore the probability of a graduate becoming a deputy magistrate and a poet is $1/50 \times 1/25 = 1/1250$ i.e., 1 : 1249.

Probability of the occurrence of one or the other of two repugnant events.

(2) The probability of the occurrence of one or the other of two events that cannot concur is the sum of the separate probabilities. This rule considers the probability of inconsistent events that cannot concur. Suppose the probability of a graduate becoming a deputy magistrate is $\frac{1}{50}$ and the probability of a graduate becoming a lawyer is $\frac{1}{7}$. Therefore the probability of a graduate becoming either a deputy magistrate or a lawyer is $\frac{1}{50}+\frac{1}{7}=\frac{57}{350}$ i.e., 57 : 293. Suppose out of 1000 men only one is drowned and out of 3000, 7 are devoured by tigers. Then the probability of a person being either drowned or devoured is $\frac{1}{1000}+\frac{7}{3000}=\frac{1}{300}$, i.e., 1 : 299.

Rule for calculating the cumulative value of independent evidence.

(3) The rule for the cumulation of independent testimonies in favour of a fact is found by multiplying together the fractions representing their separate improbabilities and then subtracting the product from unity. If a witness speaks six truths when he speaks one lie his improbability of speaking the truth is $1-\frac{6}{7}=\frac{1}{7}$. If another independent witness speaks seven truths when he speaks three lies then his improbability of speaking the truth will be $1-\frac{7}{10}=\frac{3}{10}$. If both of them testify to the same fact then the probability of the fact being true will be $1-(\frac{1}{7}\times\frac{3}{10})=1-\frac{3}{70}=\frac{67}{70}$, i.e., 67 : 3.

Bain's rule is different.

But according to Bain the rule is different. His rule is as follows :-The rule for the cumulation of independent testimonies in favour of a fact is to

multiply the numbers expressing the proportionate value of each testimony. According to this rule the proportionate value of the first witness of the above mentioned example will be 6 : 1 and the proportionate value of the second witness will be 7 : 3. Therefore the joint effect of their testimony will be $6 \times 7 : 1 \times 3$: or 42 : 3 or $\frac{42}{3}$ which is different from the result arrived at by the previous rule. On account of the fact that there is no mathematical sanction for the multiplication of ratios as has been suggested by Bain's rule, this rule has been rejected altogether and a new one has been substituted by logicians. There is no justification for the revival of this discarded rule.

Criticism of Bain's rule.

If A, B, C, and D are the independent signs of X then in finding out the probability of the occurrence of X when all these signs are present we should apply this rule i e., we should multiply the separate improbabilities and then subtract from unity their product.

(4) The rule for the deterioration of testimony in passing from one person to another, that is, for the weakening of traditional evidence through the lapse of time, is to multiply the fractions expressing the separate probabilities.

Rule for calculating the value of dependent evidence or hearsay.

By this rule we ascertain the true value of hearsay evidence. Suppose the probability of A's speaking the truth is $\frac{7}{8}$, the probability of B's speaking the truth is $\frac{3}{4}$ and the probability of C's speaking the truth is $\frac{5}{6}$; and suppose B gets an information from C and B then gives this informa-

tion to A and if A gives evidence regarding the events which he heard from B and which B heard from C then the value of A's evidence will be $\frac{7}{8} \times \frac{3}{4} \times \frac{5}{6} = \frac{35}{64}$. Thus the value of hearsay evidence is very small and it is for this reason that it is rejected in law courts, while reliance is placed on corroborated testimony.

Probability of dependent events.

This is also the rule for the calculation of the probability of *dependent events.* Suppose the occurrence of X depends on P and the occurrence of P depends on A. Hence X and P are dependent events. Suppose the probability of the occurrence of P when A occurs is $\frac{7}{8}$ and the probability of the occurrence of X when P occurs is $\frac{5}{9}$, then the probability of the occurrence of X when A occurs will be $\frac{7}{8} \times \frac{5}{9} = \frac{35}{72}$, i.e., 35 : 37. Carveth Read states this rule as follows :—If two events are dependent each on another, so that if one occur the second may or may not, and if the second a third : whilst the third never occurs without the second, nor the second without the first ; the probability that if the first occur the third will is found by multiplying together the fractions expressing the probability that the first is a mark of the second and the second of the third. One cannot be a graduate without being a matriculate and one cannot be an advocate without being a graduate, but it does not follow that every matriculate becomes a graduate or every graduate becomes an advocate. Hence the probability of a matriculate becoming an advocate is found by multiplying the probability of a matri-

culate becoming a graduate with the probability of a graduate becoming an advocate.

Direct and Indirect evidence.

11. **Evidence.** There are two kinds of evidence, viz., direct and indirect. It is said to be direct when a person makes a statement about a fact which is required to be proved. Suppose it is required to be proved that A murdered B. If a witness says that he saw A killing B then his evidence will be direct.

Evidence is said to be indirect when a person makes a statement about circumstances connected with the fact which is required to be proved or from which the subject matter of proof can be inferred. Such an evidence directly proves the circumstances in which the fact to be proved occurs while it indirectly proves the fact which we are required to establish. Such an evidence is called **Circumstantial evidence.** If a person makes a statement that he saw A running away immediately after the occurrence and that he had a sword in his hand and that there was blood in his cloth then his evidence will be circumstantial in nature. An evidence is said to be hearsay when it is based on the information received from another and not on the personal knowledge of the person giving the evidence. We have seen already that such evidence has very little logical value and is ordinarily rejected in the law courts.

Circumstantial evidence.

Hearsay evidence.

12. **Fallacy in Probable Calculation.** Carveth Read has given the following warnings in applying the doctrine of probability :—"Not to

make a pedantic parade of numerical probability, where the numbers have not been ascertained : Not to trust to our feeling of what is likely, if statistics can be obtained ; Not to apply an average problility to special classes or individuals without inquiring whether they correspond to the average type ; and not to trust to the empirical probability of events, if their causes can be discovered and made the basis of reasoning which the empirical probability may be made to verify."

C. Read's warning.

When these cautions are neglected fallacies are committed. The greatest fallacy of probable reasoning is to rush to certainty and to apply the probable conclusion to the individual instance. Besides fallacies are committed in applying the rules of probable calculation.

Three kinds of fallacies.

[For further study of the subject students are referred to Dr. Venn's Logic of Chance.]

13. **Exercises.**

1. Explain and illustrate the meaning of Chance and Probability from the popular and the scientific standpoint.

2. Distinguish between Chance and Probability. Show how Probability is represented mathematically.

3. What is Chance and how is it eliminated ?

4. State and illustrate the rules for the calculation of chances. How are these rules arrived at ? What kind of truth is established by these rules ?

5. Explain the Grounds of Probability.

6. What do you mean by Statistics and the average aud how are they connected with Probability ?

7. Explain the relation between Probability and Indnction.

8. Distinguish between causal and casual phenomena. Can there be any casual phenomena from the logical standpoint ? If not, why does Logic consider Chance and Probability ?

9 Explain the remark : Probability ascertains the value of *may*.

10. Explain Persona' Equation, Direct and Indirect Evidence and Circumstantial Evidence.

11. Explain and illustrate the fallacies committed in connection with probable calculation.

12. Given two premises of the form : Most B's are C, Most A's are B, can any inference be drawn ? If so, of what kind and on what condition will its value depend ? Give examples.

13. What is meant by Chance ? Give example. How is Chance eliminated ?

14. Give with examples the rules for the calculation of Probabilities.

15. What is Probable Reasoning ? Discuss the relation of Probability to Induction. State and illustrate the rules for the combination of probabilities.

16. Is there such a thing as chance ? Discuss the relation between chance and causal connection, and indicate what is meant by a calculation of probabilities.

17. Explain the following :- (a) The event A is probable. (b) The probability of the event is 1/6. (c) The events A and B occur together by chance.

18. What is a probable argument ? How would you calculate probability ?

19. Explain the relation in which Probability stands to Induction.

20. The Inductive Reasoning is merely probable. Do you accept this view? Give reasons for your answer.

21. The probability of a baby living up to the age 30 is 1/5; and if it lives up to that age then the probability of its being well educated is 1/4: and if it is well-educated the probability of its becoming a Minister is 1/70. What is the probability of a baby becoming a Minister?

22. Suppose in Bihar the probability of dying of fever is 1 : 7; the probability of dying of cholera is 2:1 and that of consumption is 1:3. What is the probability of a person dying of any one of these?

CHAPTER XI

Demonstration and Necessary Truth.

1. **Demonstration.** By Demonstration we mean a process of reasoning by which we make a thing so clear and certain that there remains not the slightest doubt regarding its truth. There are two forms of Demonstration, viz.,

(i) *Demonstration of an immediate truth*, i. e., a particular fact or phenomenon. In demonstrating an immediate truth we are to make it an object of observation or experiment, i. e., of direct perception. Thus a thing is demonstrated when we actually perceive it with our sense organs; and when there is actual perception of this kind there remains no doubt regarding its truth. This kind of demonstration is to be met with in chemical laboratories where it is shown how a combination of hydrogen and oxygen makes water. It is for this reason we find a demonstrator in every chemical laboratory who actually shows his students by experiments the various truths of chemistry. Such a method of demonstration may be said to be the **Method of Illustration.** But as a method this is defective though it is spectacular and popularly convincing. A truth always involves a universal element, e. g., the chemical truth that H_20 makes water supposes that in all enses H_20 makes water.

Hence it supposes infinite number of instances in which this combination can occur. We can however perceive only a few cases of these combinations. Besides we cannot attain certainty when we base our reasoning simply on the number of instances and not on their nature. In many cases of perception our doubt is not removed as in magical performances and seances. Hence every case of perception cannot be said to be demonstration. That form of perception which gives us complete conviction as to the truth of the object is said to be demonstration. Logic, we have seen, is concerned with inferential knowledge and so it is only indirectly concerned with demonstration of this kind.

(ii) **Demonstration of Mediate truth.** In Logic we are concerned with the demonstration of mediate or inferential truth. When a conclusion of an inference or deduction has been proved conclusively, i. e., when there remains no manner of doubt as to the truth of the conclusion then we say that the conclusion has been demonstrated. Thus demonstration is opposed to probability. Now in order to have demonstration or absolute certainty we require two things, viz., (a) that the premises from which the inference is drawn are absolutely true, i. e,, necessary and certain ; and (b) that the conclusion follows necessarily from the premises, i.e., the process of reasoning must be syllogistic or deductive. Thus demonstration is possible when the premises are axioms or necessary truths and the reasoning is deductive. We know that in mathe-

Conditions of Demonstration.

Illustrations.

matics we start from axioms which are absolutely and necessarily true and the process of reasoning is completely deductive. So the conclusions of Mathematics are demonstrative. The proof of Geometrical theorems is demonstrative in character.

In Induction and other kinds of reasoning such as analogy and the like our conclusions are more or less probable as we proceed from the known to the unknown. So we cannot have demonstrative truth in Induction. Similarly in ordinary syllogistic argument we start from general propositions which are more or less probable and consequently the conclusions are more or less probable. Hence in ordinary deduction we cannot have any demonstration.

We may note in this connection the view of the Nominalists who maintain that every truth is probable and that nothing is absolutely certain. Whereas the realists maintain that there are some truths such as the axioms and the laws of thought which are absolutely true. Hence we see that according to the Nominalists demonstration is impossible whereas it is possible according to the Realists.

But modern logicians want to extend demonstration to Induction also. Simple mathematical truths and the law of gravitation about which no one entertained any doubt are being doubted by many scientists and mathematicians, e.g., Einstein and Whitehead. Besides the modern method of Induction involves a considerable amount of deduction as it is grounded on the law of causation about which we

entertain no doubt. Such an induction gives us rational certainty. Hence it is maintained by many logicians that we can have demonstration even in inductive reasoning. Coffey, for instance, writes in his *Science of Logic*, "The term 'demonstration' seems by preference to be applied to the process by which we connect abstract truths with their first principles ; and 'explain' to the process by which we connect the concrete existence and happening of things and events with their causes, and so come to understand the modes in which, or the laws according to which, they are produced by those causes. We may know that the three angles of a triangle are equal to two right angles without knowing why ; and we may know that ice begins to form on the surface of a pond and not at the bottom, without knowing why. To answer the first 'why' is to demonstrate a theorem in geometry ; to answer the second is to explain a phenomenon in physics. To demonstrate truths is simply to show their connexion with simpler truths which we already understand, and ultimately with first principles : to show how they are involved in the latter, to harmonize and fit them in with that part of our knowledge to which they are logically or rationally akin. To explain facts is simply to show why they happen, how they occur, how they are connected with their causes, what these causes are, and what are the laws according to which they bring those facts about. We demonstrate consequent by antecedent until we reach first principles ; we explain effects by causes

until we reach remote causes, and ultimately, the One, Uncreated First cause."

Though a distinction has been drawn here between domonstration aud explanation yet the purpose of demonstration is not different from that of explanation for both of them try to make some fact or phenomenon intelligible to our understanding. In the final analysis of both the processes we are bound to go to the first principles. But let us reserve this higher topic for metaphysics.

2. **Necessary Truths.** Necessary truths are those truths which are self-evident, eternal, and immutable. We call them *self-evident* because they require no proof for their validity, they are assumed in all kinds of reasoning and as such they are called *ultimate.* We call them *eternal* and *immutable* as they cannot be changed or made otherwise by any power, finite or infinite. We know for example that the axioms of mathematics, the laws of thought cannot be made ortherwise by any power. Similarly the truths that two and two makes four and that two straight lines cannot enclose a space cannot be altered by any body, not even by God almighty. Whereas the contingent truths such as the rising of the sun in the east, the mangoe being ripe, the human beings having legs and not wings and the like may be altered by the will of the almighty power working in nature. The other peculiarities characterising necessary truths are their *universality*, *necessity* and *immediacy*. They are *universal* because they are believed to be true by all men even

unknowingly. There is no one who can be found to deny their validity. They are *necessary* because we are compelled to accept them in our thinking and action. Their opposites are also unthinkable. They are immediate because we do not get them through any other means, data, medium or evidence, i e., we do not establish them by any reasoning whatsoever. but we know them directly and immediately by intuition.

We may mention in this connection the views of *Bain* and *Spencer* about necessary truths. (a) Bain defines necessary truths as what must be true and that which is opposed to the contingent truth which may or may not be true. This definition cannot be accepted (i) because it is circular as the word *must* signifies necessity ; in other words Bain's definition is equivalent to saying that neceasary truths are those which are necessary ; and (ii) because the second part is wrong for there can be no truth which may be true or may not be true. What is true can never be untrue. (b) Spencer describes necessary truth as one the opposite of which is unthinkable or inconceivable. This again is fallacious on the ground that our inconceivability cannot be the ground of necessity,for there are truths the opposites of which we cannot conceive but they are not necessary, e.g., we can hardly conceive that man will walk on head, that we shall hear with our eyes and see with our mouth, that the heavy bodies will go up instead of falling down and the like, but these are not necessary truths. So it is not a fact that a truth is necessary

because its opposite is unthinkable, but what is true is that its opposite is unthinkable because it is necessary. Necessary truths being grounded on the very form of thinking cannot be properly defined.

3. **The use of** **ecessary truths in Logical Thought.** Logical thought or reasoning of any kind assumes the first principles, axioms or necessary truths. Without assuming them it is impossible for us to think or argue ; in fact they are inherent in all thought and reasoning, and for that reason they are the grounds upon which inductive and deductive arguments are based. We may point out that the fundamental laws of thought, the *Dictum* of Aristotle constitute the ground of deduction, while the Uniformity of Nature and the Law of Causation constitute the foundation of Induction.

4. **The Source of Necessary Truths or how they are known.** According to the empiricists, strictly speaking, there cannot be any necessary truth The so called necessary truths, they maintain, like any other truth are based upon experience. Spencer maintains that we determine necessary truths by observing whether their opposites are unthinkable. This empirical view however cannot be accepted because every experience presupposes the necessary truths. Their real source lies in our intuition, i. e., we become directly conscious of them. Just as we perceive the colour of a flower, hear the humming of a bee, and the like, with our sense organs, so with the help of our mind we become directly conscious of the existence and validity of

the necessary truths. In short, the source of the necessary truths is *apriori* and not *aposteriori*. We may note here that there are some necessary truths which are proved by demonstration, i,e., by deducing them from the axioms and the laws of thought.

5. Exercises.

1. Explain what you mean by Demonstration. What are its forms? Can there be any demonstration in inductive investigation?

2. In what forms of reasoning is demonstration possible? What are the conditions of Demonstration?

3. What is the function of the Demonstrators found in the laboratories? What method do they follow? What logical value does such a method possess?

4. Explain the Method of Illustration. Has it any connexion with Demonstration? What is its logical value?

5. Distinguish between Demonstration and Explanation.

6. Explain the characteristics of Necessary Truths. Are they connected with Demonstration? How do we get these Necessary Truths?

7. Mathematics and its applications are called the 'exact sciences,' and their conclusions are characterised as systems of necessary truth: show what is implied in these designations and whether they are justified or not.

8. What is meant by Demonstration? What kinds of inference are of demonstrative character and what kinds are nerely probable? Explain the reason in each case and give examples.

9. What is meant by Necessary Truth? Do you think that there are any truths which can be known to be necessary? If so, how can they be known to be such, and what will be the use of such truths in logical thought?

CHAPTER XII

Explanation.

1. **Popular Explanation.** The word explanation is derived from Lat. *explano—ex*, out of, and *plano*, to make plain. Therefore etymologically it is a process by which something is made plain. Popularly Explanation means exactly the same thing. Hence popularly we may define explanation as a process by which something is made plain or clear to one's understanding. When a thing or a law is made intelligible to us it is said to be explained. When we fail to understand the nature or meaning of a thing or how it has been brought into existence or the laws that govern it we require an explanation. Thus explanation supposes a previous state of perplexity or doubt and the process by means of which this perplexity or doubt is removed is called explanation. But the understanding of a man is not stationary. It varies from man to man, and even in the same man from time to time. Therefore popular explanation which aims at making a thing clear to the understanding is a variable thing and not stationary. A child's understanding is easily satisfied by analogical statement, e.g., a child is satisfied when it is said that the shaking of the earth takes place on account of the shaking of the hood of the serpent

on which the earth rests. Similarly the understanding of a village woman is satisfied when it is said that her son has fallen ill on account of the wrath of a particular goddess. An ordinarily educated man is satisfied when it is said that a particular man has got bronchitis on account of the changing weather and sudden exposure. But a scientific man enquires into the germs that produce bronchitis. Thus popular explanation is variable in nature, but scientific explanation is steady and invariable.

Popular explanation is concerned with the superficial characteristics of things. It is grounded on any form of likeness and sometimes on rough analogy or supernatural agencies, while scientific explanation traces phenomena to their causes and the law of operation of these causes.

Popular explanation sometimes consists in substituting a thing that seems to be familiar for a thing that seems to be strange while scientific explanation resolves a phenomenon into factors about which we previously knew little or nothing, e.g., the rusting of iron which is a familiar phenomenon is explained by oxidation with which we are not familiar though it is well known to the scientists and to them it is simpler than the rusting of iron. So in science and Logic the simplicity of a phenomenon is not judged by the popular standard.

Popular explanation is concerned with a particular case and its special cause or condition or more correctly occasion, while scientific explanation aims

at discovering a causal connection and with its help tries to make a generalisation with a view to establish a law.

2. **Scientific or Logical Explanation.** A thing or phenomenon is scientifically explained when we assign a cause to it. Jevons says, "Scientific explanation consists in harmonising fact with fact or fact with law, or law with law so that we may see them both to be a case of one uniform law of causation." Carveth Read has defined scientific explanation as a process which consists in discovering, deducing, and assimilating the laws of phenomena. But these 'discovering', 'deducing', and 'assimilating' are possible only when causal relations have been already established. Where causal relations are not to be found empirical laws should be found out in order to explain the phenomenon in question. But the explanation by an empirical law is not satisfactory from the logical standpoint. The essence of explanation, therefore, is always a discovery of the causal relation and the reference of the facts of our experience to such a causal relation. Thus it is clear that explanation is possible only when we have causal relations established by previous induction, and so explanation may be said to be the goal of induction.

The aim of every logician is to form an idea of the world as a system of laws. Now the function of explanation consists in accommodating the phenomenon to be explained to a suitable place in this complex idea of the world as a system of laws. We

have doubt and perplexity when a thing or phenomenon does not fit in in this system of laws which we have formed already and this doubt is removed when the phenomenon is assimilated to the system of laws. Such an assimilation requires the detection of the essential feature of the objects to be explained and a reference to the cause producing the phenomenon and the mode of operation of this cause. We have seen already that scientific generalisation is possible only through the establishment of the causal relation. Hence underlying explanation we have assimilation and generalisation. When we are required to explain a law we deduce it from a higher law, i.e., we show that it is an instance of that higher law, and in this way it is assimilated to that higher law. Again a large number of laws are sometimes generalised into a higher law and thereby assimilated to that higher law. Thus assimilation and generalisation go together.

The nature of logical explanation varies according as the problem belongs to one science or the other. In natural sciences such as Biology explanation takes the form of *classification*. Its business becomes there confined to the finding of resemblances between the phenomenon in question and other phenomena. In Mathematics explanation becomes identical with *proof* and consists in showing that the thing given for explanation repeats under different conditions the definitions and axioms already assumed and the theorems already demonstrated. In the concrete sciences explanation

means the *discovery* and the derivation of laws including within it the discovery of the causes of phenomena. When a cause cannot be discovered the mere discovery of an empirical law of co-existence such as, white tom cats with blue eyes are deaf, serves the purpose of scientific explanation. But underlying all these forms of explanation there is assimilation and generalisation of phenomena.

3. **The Modes or Forms of Scientific Explanation** Ordinarily three forms of scientific explanation are considered in Logic, viz., *Analysis*, *Concatenation*, and *Subsumsion*, but I have added a necessary fourth form, namely, *the discovery of the cause* which follows from the very definition of explanation. The following, therefore, are the forms of scientific explanation :—

(1) We may explain a particular thing or phenomenon by referring it to its cause. In this case we show how the particular thing or phenomenon arises out of the ascertained ground or cause, e.g., a particular case of death is explained by poison and the flood in a river is explained by the heavy rainfall in the mountain or the melting of a huge glacier.

(2) We explain a complex phenomenon by analysing it into its component parts and showing the connexion existing among these parts, and also showing how these parts individually operate and how they jointly realise a common goal. Similarly the joint effect is explained by discovering the various conditions and showing how they produce

the joint effect in question. Scientific analysis is not simply concerned with the *what* of a thing but with the *how* and *why* of a thing and so in it we generally try to discover the causes and the laws of these causes. In a complex phenomenon we find by analysis that many causal agencies are operating according to the various laws of their own. Now when we find out and state these causal agencies bringing about the phenomenon and the laws in accordance with which they are acting, we are said to explain the phenomenon scientifically, e.g., the rise of water in the common pump is explained by analysing the phenomenon into the forces acting upon the pump, viz., the pressure of the atmosphere, the laws of motion, and the distribution of forces or pressure in a liquid and the nature of liquid that it always tries to keep the same level. Similarly the elliptical orbit of a planet is explained by the operation of two forces viz., the tendency of the planet to move in a straight line and the attraction of the sun drawing it towards the centre of the sun. Similarly the path of a projectile is explained by finding out the initial force and its inclination, the gravity, and the resistance of the air.

(3) We explain the relation between a cause and its remote effect by pointing out the intermediate links existing between them, i.e., by interpolation and concatenation of the intermediate causes. As for instance, we explain the proverb "No pains no gains" by showing that by taking pains we do some work and thereby get some

remuneration for our work. So if we refuse to take any pain there will be no work done by us and so we shall not be able to get any remuneration or gain. Similarly the argument that "no cats no clover" is explained by showing that cats destroy rats and these rats destroy the nests of humble bees, and these humble bees are necessary for fructifying red clover. So it follows that if there be no cats there will be rats, and these rats will destroy the nests of the humble bees and so the humble bees will fly away and so the red clover will remain unfructified and the clover crop will fail. Thus we understand the saying "No cats no clover". This form of explanation seems to be more popular than scientific.

(4) We explain a law or a series of laws by subsuming it under a more general law. Secondary laws are explained by bringing them under a more general law, e. g., the law of falling bodies, the tides and the orbits of planets are explained by subsuming them under the universal law of gravitation. Similarly the purification of blood by breathing, the burning of a candle and the rusting of iron are all subsumed under the general law of oxidation. This form of explanation is called subsumtion and is identical with assimilation and deduction. Because when a lower law is subsumed under a higher law we simply assimilate it to the higher law or in other words deduce it from the higher law. Thus we find that the scientific outlook in explanation is clouded by the forms of explanation commonly known as concatenation and subsumtion.

4. Relation of Explanation to Deduction, Induction, and Hypothesis. Explanation is a peculiar process closely related to Induction as well as to Deduction Some logicians are for making explanation a process of Induction. They lay stress upon the fact that "scientific explanation consists in harmonising fact with fact, fact with law, or law with law so that we can see them both to be cases of one uniform law of causation.' Thus when we are required to explain a particular event we show how that event has been caused into existence and the causes which have brought the event into existence do work according to general laws. Similarly we explain a law by bringing it under a more general law. Thus explanation involves generalisation. Induction also takes into consideration the points of resemblance amongst the data of inference and on the ground of this resemblance we generalise the particular events and draw the inductive conclusion. Thus Induction and Explanation both depend on similarity and generalisation. On the other hand when there is no such resemblance there can neither be any generalisation, nor induction ,nor explanation.

It has also been pointed out that real scientific explanation of facts consists in discovering their causes and the explanation of laws consists in deducing them from higher laws. But these causes are to be established by inductive reasoning and the laws which are not axiomatic are also established by the inductive process of reasoning. Thus it is induction which makes explanation possible. Hence

it is truly said that explanation is the goal of induction and induction is the process by which explanation is made possible.

But we may notice here that explanation contains within it some processes of deduction, for we know that explanation consists in deducing the particular fact or law in question from a cause or a law. When we are to explain a fact, e. g., the rise of water in a common pump we do it by showing how it follows from the working of the causes or laws governing the fact, viz, the law of the atmospheric pressnre, the law of the distribution of force in a liquid, the law of gravity, etc. But we should remember that these laws are not assumed to be true but are already found to be true by means of induction. Ordinary deduction aims at formal truth and so in it the premises are assumed but explanation aims at material truth and so the laws and causes by means of which objects are explained cannot be assumed but should be established by means of previous induction. So explanation is possible at an advanced stage of science when some laws have been established by induction. Hence explanation may be said to be a process by which we show how an unknown or new fact or law is the reproduction of the known facts or laws in a new form. This process of reasoning is surely deductive in character. But we should bear in mind that such a deduction is different from syllogistic deduction which aims at formal truth and in which the premises are assumed.

Explanation is closely related to Hypothesis. We have found already that the aim of hypothesis is to discover the cause of a phenomenon or the law according to which certain agents behave or the collocation necessary for the production of a phenomenon. Now when these things are found out the phenomenon under investigation is said to be explained. Thus hypothesis aims at the explanation of the facts and phenomena experienced by us. Similarly the aim of classification is the explanation of the facts to be classified. An object is brought under a class when it possesses the essential attributes of that class, i. e., when it is assimilated to that class. We have found already that this assimilation is a form of explanation. In modern scientific classification the nearness of descent has been substituted for the old principle of affinity or resemblance, and so nowadays things that are similarly produced are brought under a class. Thus in modern classification we are required to find out the causal basis, and we have seen already that in explanation also we are required to find out this causal basis. The remarks of Hobhouse that "in classifying we describe what is ; in explaining, what must be, and why it must be : in classifying, we do not look for antecedents ; in explaining, we so analyse the antecedent as to show the ground for the consequent" are applicable to the old method of classification which viewed the world in its statical aspects. But these are not applicable to the modern classification as determimed by the doctrine of

evolution which views the world in its dynamic aspect.

In the same way it can be pointed out that definition also aims at explanation, for a term is understood by us when we get its definition. When we come across a difficult word we open a dictionary for its meaning or definition. When the meaning is found out the word is said to be explained. Definition also involves classification as in it we are required to mention the genus and the differentia and classification has been already found to be a process of explanation. Besides definition unfolds the essential attributes implied by the word defined and the detection of these essential attributes is the basis of assimilation which is a form of explana nation. In fact the aim of all knowledge is the explanation of the diverse facts of our experience. Hence it can be safely said that the explanation is the goal of all the sciences and the processes of logic.

5. **The Limits of Explanation.** There are certain things, facts, and laws which cannot be explained either on account of these facts and laws or on account of the imperfection of the human understanding :—

(1) *We cannot explain the fundamental states and processes of consciousness.* These states and processes are peculiar in kind and do not resemble with one another and therefore they cannot be deduced from or generalised into any other state of mind. So they cannot be explained. We can feel

these states and processes but we cannot explain them. The sensations of smell, taste, sound, pleasure, pain etc., fall in this class. It should be noted that where deduction and assimilation are not possible explanation also is not possible.

(2) *The primary qualities of matter* such as extension, figure, resistance, weight, motion, density, elasticity etc, cannot be explained. They are also peculiar and distinct in kind. We know that they exist but we do not know why they exist. Here also assimilation and deduction are impossible.

(3) *We cannot fully and completely explain nature, its objects and events*, for we know that scientific explanation consists in referring things and events to their causes. Now these causes also have their causes, and so on. Thus we see that in order to fully explain a thing or event we are to arrive at the first cause of the universe together with the intermediate causes which is simply an impossible task. Hence it follows that we cannot explain any thing or event fully and completely.

(4) We cannot explain *the fundamental axioms of thought* such as the uniformity of nature, the law of identity, non-contradiction, and the excluded middle. These are assumed in all kinds of thought and reasoning. So every explanation also assumes these, and so they cannot be explained

(5) *The individual characteristics* of facts and phenomena cannot be explained because they are practically infinite in number and character. So these cannot be assimilated to any other known fact

or law. A common pencil which we use every day and night is related to all the things of this world including the distant stars. Besides the arrangements of the atoms and the fibres of the wood of the pencil and many other things by which we distinguish one pencil from another cannot be explained. Similarly the *personality* of a man is so very complex that it cannot be assimilated to any known fact or law and so it cannot be explained. We know the particular things and phenomena only partially and so we cannot explain them fully.

6. **The Fallacies of Explanation** The errors or fallacies which we generally commit in explaining a fact or law are of various kinds e, g.,

(1) When we are asked to explain a thing or phenomenon we sometimes say that it is too simple to require any explanation or we say that it is known to every body. But this surely is not explaining the thing or phenomenon—this is in a way refusing to explain the fact or phenomenon.

(2) When we demand an explanation for every fact or phenomenon which we meet we commit a fallacy for we have seen that there are many things such as axioms, the primary qualities of matter and mind which cannot be explained.

(3) It is a fallacy to explain a fact or phenomenon by analogy, e. g., in explaining a camel if we say that it is a ship of the desert or in explaining milk we say that it is like water we surely advance analogy for explanation.

(4) Similarly it is wrong to explain a fact or

phenomenon by giving only its synonym. Such an explanation is said to be circular explanation and it involves the fallacy of *petitio principii*. Pleasure is a kind of happiness. Opium produces sleep because it has soporific virtue. These are the instances of circular explanation.

Circular explanation.

(5) It is wrong also to explain a fact or phenomenon by substituting a familiar conception for an explanation, e. g., if in explaining the eclipse of the moon we say that it is caused by the swallowing up of the moon by a demon we shall be guilty of a fallacious explanation.

Figurative explanation.

(6) Explanation by means of fictitious agents or supernatural things are erroneous. Popular explanations also are fallacious. It has already been pointed out that analogy is no explanation. Similarly negative statements cannot be treated as explanation,

Supernatural explanation.

7. Exercises.

1. What do you think to be the nature and function of Popular Explanation ?
2. What do you consider to be the nature and function of Scientific Explanation ?
3. What are the forms of Scientific Explanation ? Explain and illustrate them clearly. Can every thing be explained scientifically ?
4. Illustrate the various fallacies of Explanation.
5. Explain and illustrate Figurative Explana-

tion, Circular Explanation. Analogical Explanation and Supernatural Explanation

6. What is the relation between (a) Explanation and Induction, b) Explanation and Classification, (c) Explanation and Hypothesis, (d) Explanation and Deduction, and (e) Explanation and Definition.

7. What is meant by Explanation in Science? Describe and illustrate the different forms of Scientific Explanation. Show how Explanation is related to Induction.

8. Distinguish between Popular and Scientific Explanation. What are the limits of Explanation?

9. Discuss what is meant by Scientific Explanation and show the relation between Explanation and Classification.

10. The goal of Science and Induction is Explanation, but the explanation of nature can never be completed. Explain this.

11. Discuss the connexion between the scientific explanation of a phenomenon and the assignment of its cause.

CHAPTER XIII

Classification.

1. Definition and Nature of Classification. Classification has been defined by Carveth Read as "a mental grouping of facts or phenomena according to their resemblances and differences, so as to serve some purpose." From this definition it is clear that classification is a mental grouping as opposed to actual or physical grouping of things or objects as is found in a museum. A class implies practically an infinite number of individuals existing in the past, present, distant and future. The actual grouping of all these objects is physically impossible. In a museum only the samples or specimens of the varieties of a class are collected and so the arrangement found in a museum is not a logical classification though it illustrates logical classification and is grounded on it. It is therefore not correct to say that a class is nothing but the objects contained under it.

We also find in the definition that the mental grouping implied by it is grounded on the resemblances and differences of the objects classified, i.e., objects that resemble one another are grouped together and a class is formed with them while those which differ from these objects are excluded from this class. In scientific classification these points of resemblance must be essential and

at the same time numerous, whereas popular classification is grounded on the superficial points of resemblance.

From the definition we also find that the mental grouping of facts must have some purpose in view. Therefore random, aimless grouping of facts cannot be said to be classification. The aim of scientific or logical classification is the attainment of knowledge of the objects classified with a view to form a systematic conception of the various facts and phenomena experienced by us. The aim of popular classification on the other hand is the realisation of some special purpose other than the knowledge of the objects classified. The same objects can be arranged or grouped into various ways according to the principle selected or the purpose for which the classification is made, e.g., the students of a college can be arranged according to their accademical stage, according to their age, according to their religion, according to their district, complexion, health, strength, caste etc. We have seen already how terms and propositions are classified in different ways according to different principles. The books of a library also can be classified according to the language in which they are written, according to their subjects or size or according to the alphabetic order of the names of their authors or according to the year of their publication, etc.

2. Forms of Classification.

Classification is generally divided into two classes, viz., **popular** and **scientific**. When we

classify birds according to their beauty our classification is termed popular or artificial because the points of resemblance and difference are wholly superficial or artificial. When we know the beauty of a bird, the size or colour of a book we hardly know what it is. So this sort of classification hardly gives us any information regarding the things and phenomena classified and so knowledge cannot be the end in view here. It only serves some practical purpose. For this reason such a classification is also called **practical** or **technical** classification.

The end in view in *scientific classification*, on the other hand, is the direct attainment of the knowledge of the objects classified. Indirectly it may serve many other purpose practical or artificial. When our classification is grounded on the most numerous and the most essential points of resemblance it is called scientific. In order to make a scientific classification we should carefully analyse the facts and phenomena and find out the essential points in which they resemble one another and base our classification on these points of resemblance. As this sort of classification gives us information as to the inner nature of the classified objects it is also called **natural classification**. But strictly speaking by natural classification we mean the mental grouping of the objects of this world into the classes which are found to exist in nature from the beginning of this world and are believed to be different from one another so completely that there is no possibility for one class being developed into another.

Classification of books into History, Mathematics, Literature; etc is one of this kind Similarly the classification of animals into rational and irrational also falls into this class. The classification of animals according to their anatomical structure is 'a scientific classification.

Artificial classification is grounded on superficial resemblance and has a special end in veiw. But essentially different objects may agree in superficial attributes. Books on history and mathematics may be similar with respect to their binding and size. Hence in artificial classification objects which are essentially different may be grouped into a class while objects which are essentially similar may be placed into different groups on account of their superficial difference, e. g., when books are classified according to size, books on mathematics will fall into different groups because they are of different sizes.

Strictly speaking all forms of classification whether popular or scientific may be termed artificial for both of them serve some human purpose and are formed by human beings. Things and phenomena that are classified by us do not by themselves form into classes All classifications again may be called natural because the points of resemblance on which classification is grounded exist in the objects which are classified. The colour, size, etc. on which artificial classification is made all exist in the objects classified and are not formed by the imagination of the person who classifies. Hence the division of

classification into natural and artificial is not sound logically, though practically it is quite useful.

Classification again may be **general** and **special**. It is called special when it has some particular, special or practical purpose to serve such as gardening, hunting, racing, etc. It is called general or scientific when the end in view is merely knowledge. This sort of classification can be met with in Zoology and Botany.

3. **Classification by Definition.** This form of classification consists in first of all defining the class that we are going to form and then gathering into it all the objects possessing the attributes indicated by the definition, and rigidly excluding from the class objects that do not possess any one of the attributes mentioned by the definition. According to Mill all scientific classification is grounded on the definition of the class formed, because in a scientific classification we should group together into a class all those objects which resemble with respect to a large number of essential attributes. Now these essential attributes constitute the definition of the class formed. Thus the very definition of scientific classification points out that it is grounded on definition.

4. **Classification by Type.** In opposition to Mill, Whewell supports the doctrine of Classification by Type. By **Type** is meant a typical, or eminent example, model or representative of a class embodying all the essential characteristics of that class in a conspicuous way. Classification by Type consists

in first of all finding out the type and then forming a group around this type with all those objects which resemble this type. In such a classification the selection of the type is the most difficult task because the type is not any and every member of a class—it is that member which possesses all the qualities of the class in a prominent degree and these qualities constitute the definition of the class formed. Thus a type supposes the definition of the class of which it is a type and so classification by type requires the help of definition. Yet the question has been asked whether in classification we begin with a definition or with a type. Naturally and psychologically we do begin with a type, but scientifically we ought to begin with a definition. Ordinarily we take a type and form a class around it, i.e., bring all the objects resembling this type under one class. A child, e.g., first comes to know a dog and using it as a type forms the class **dog** with all the creatures resembling that type. But in such a classification any and every individual serves the purpose of a type.

Both the processes of classification have got their own importance. There are objects which cannot be defined and of which we hardly know any thing and yet they are to be classified. In a case like this we follow **Whewell**, get a type and form a group around it The greatest advantage of a type is that it marks the centre of a class and it recognises the dynamical aspect of nature. While definition marks the boundary of a class and recognises only the statical aspect of nature. Evolution tells us

that there is a continuous process of development going on in nature and the type represents the highest developed individual of a class and the marginal instances represent the lowest developed individual of a class. Definition ignores this development and gives us an account of the important attributes which are common to all the individuals of a class, undeveloped and the highest developed being. But accurate idea of a class cannot be formed from the attributes possessed by the undeveloped members of the class. The best possible idea of a class can be formed when we are shown the typical members of a class. But it has already been pointed out that type supposes definition and so classification by definition cannot be ignored.

According to **Jevons** when we know our objects pretty well we should begin with a definition otherwise our classification would not claim any scientific accuracy. But there is no denying of the fact that a type always suggests a definition and it is for this reason a type always helps us in classifying objects. Thus we conclude that both these forms of classification have their own value.

5. *Classification by Series.* When we arrange the objects of a class in a graduated scale according to the variation of some feature or features our arrangement becomes a classification by series, e.g., the students of a class can be arranged in a series according to the development of their intelligence. If we trace the genealogy or development of the different varieties of the same species and arrange

them in a genealogical table showing their descent or gradual variation then our arrangement will be called classification by series. "Such a form of classification is convenient and useful when there is a progress and where the property developed has a commanding importance" (Bain). We know that there is a class of animals which possess backbone. But this backbone has undergone wonderful variations in mammals, birds, reptiles, amphibia and fishes. If we arrange all these creatures according to the development of their backbone then our classification will be a classification by series. Mill lays down two requirements or conditions of classification by series, viz., (i) we should first of all bring into one class all kinds of objects which possess a particular attribute in whatever form, and (ii) secondly we should arrange all these objects in a series according to the degree in which they exhibit, beginning with those which exhibit most of it, and terminating with those which exhibit least (*System of Logic;* Bk. IV, Ch. VIII sec.1).

Such a classification is also called *Classification as a gradation of classes* because in it classes are arranged according to the gradual variation of these classes with respect to some attribute. The students of a school or college are arranged according to the various grades to which they belong.

6. Index classification. The arrangement of the contents of a book scattered over its pages according to the alphabets of the language in which it is written is called **Index** or **Diagonistic Classi-**

fication. This sort of classification helps us in finding out a topic that is scattered over the pages of a book. Such a classification is also extended to scientific arrangement of objects. We find that one and the same attribute is possessed by a vast number of objects belonging to different classes. If we bring under one attribute all the objects that possess this attribute then this grouping will be called also index classification. Such a classification is also called diagonistic classification. According to Fowler 'such a classification is peculiarly easy of application and can be much more easily learnt than a natural system. It thus often serves the purpose of a key, by which we may easily discover the place of a group in a natural system" (*Inductive Logic*, p. 50). Such a classification is to be met with in Botany and the books on medicine.

7. *Deductive and Inductive Classification.* Classification may be either deductive or Inductive. Deductive classification is called **Division.** It consists in dividing a class into sub-classes and these sub-classes into smaller ones and so on till the lowest classes are arrived at. Thus it is a process in which we move from a bigger class to smaller ones, i.e., we proceed downward from more general to less general classes. **Inductive classification** or classification proper consists in grouping individual objects into classes according to their points of similarity and difference and these classes again into higher classes and so on till the highest class or the summum genus is reached at. In this process we proceed upward

from the less general to the more general or from individuals into classes and so this form of classification is called inductive. Both these processes are interdependent. We cannot materially divide any class without knowing and examining the individuals comprising that class. Similarly we cannot classify objects without admitting that they are of similar nature to a certain extent and framing a hypothesis to the effect that they belong to the same class, However there is no denial of the fact that in some processes deduction is prominent whereas in others induction or the process of generalisation is prominent. It is by this prominence that the nature of the process is determined.

8. **Mill's doctrine of "Real and Natural Kinds."** By Real or Natural Kinds, Mill means classes of things and beings existing in nature which are rigidly separated from one another. These classes differ from one another by a complete diameter of being. There being no similarity amongst them impassable gulfs intervene between them. so that the development of one class, e.g. monkey, into another class, e.g., man, as is supposed by the doctrine of evolution, becomes wholly impossible. These classes will remain for ever distinct and separate and no class will merge into another. The doctrine of evolution supposes a common descent, whereas the doctrine of natural kinds supposes different origin for different classes or special creation. It is for this reason that the natural kinds are separated from one another by an infinite number

of differences of which some are known and many are unknown.

The doctrine of evolution maintains on the contrary that there is no gap in nature. Classes or species of things such as plants and animals all spring from a common stock. There is no rigid line or gulf separating one class from another because a class merges into another.

9. *Classification modified by the doctrine of Evolution.* The theory of Evolution and Darwin's doctrine of the origin of species have modified the old method of classification to a very great extent. In the first place Darwin has established that all living things and beings are blood relations arising out of a common stock and that by *affinity* we should mean not simply resemblance but nearness of common descent and in classification we are simply to trace the genealogy of every form. So according to the principle of evolution we should bring under one class all those objects which are similarly generated and the general scheme of classification should be to trace the genealogy of all the different species and thereby show that they are all originated from the common stock.

In the second place the fixity of species and Mill's doctrine of natural kinds have been discredited. The theory of evolution maintains that one species becomes developed into another under the influence of circumstances. According to this doctrine classification becomes simply a representation of the natural objects as developing in time.

In the third place the nature of classification has been modified by evolution. The law of causation has been substituted for the principle of co-existence. In defining a species we ordinarily describe its co-existing attributes but according to the doctrine of evolution we are required to point out how it has sprang up from the common stock under the influence of circumstances.

10. *Classification and Definition.* Classification and Definition are interdependent because in classification we arrange individual objects into classes and these into higher ones on the basis of some essential common attributes possessed by these individual objects. Now in definition we explicitly state all these common essential attributes of the class. Thus classification cannot go on without knowing positively the common essential attributes, i. e, without defining the class. We have seen already that scientific classification is grounded on definition. But this definition remains implicit in classification. We have also found that even in classification by type we require the help of definition in finding out the type because a type possesses most prominently the essential attributes of the class of which it is a type. But popular classification which is concerned with the superficial attributes has hardly any thing to do with definition.

Similarly we cannot define a class without at the same time bringing the defined objects under a higher class. We have seen already that in defining a term we are required to mention the genus and

the differentia (Definition *per genus et differentia.*) So in defining a term we must classify it. Hence we conclude that classification and definition are the two aspects of one and the same thing.

We may note in this connection that definition is concerned with connotation whereas classification is concerned with denotation. But we have seen that connotation and denotation are interdependent and so classification and definition cannot but be interdependent.

11. *Classification and Induction.* In classification we clearly follow the inductive process of reasoning, because in it we simply start with some individual objects and after comparing and examining them bring those objects which have in common a number of essential attributes and other similar unexamined objects under one group or class. Thus the class formed contains not simply the objects that we have examined but also a vast number of unexamined objects. Thus in classification we proceed from some cases to all cases or from the particulars to the general, which is the characteristic of the inductive process of reasoning. We follow this principle also in classifying groups into higher groups. When we find that A_1 is x, A_2 is x, A_3 is x., A_4 is x, and so we conclude that A_n is x, i. e., All A's are x by the inductive process of reasoning, which is the same thing as saying that A_1, A_2, A_3, A_4, etc., all belong to a class. Thus the result of induction is classification. Similarly when we find that Ram is mortal, Jadu is mortal, John is

mortal, Mahmud is mortal, we conclude inductively that all men are mortal; i. e, Ram, Jadu, John, Mahmud, etc., are all brought under the class of mortal beings. Thus here also we find that induction leads to classification. Induction also presupposes classification because when we study a number of individuals for an inductive generalisatisn we at least tentatively suppose that these individuals belong to a class. Our examination of A_1, A_2, A_3,A_4, supposes that they belong to the same class. Similarly the examination of Ram, Jadu, John and Mahmud, etc., rests on the supposition that they all belong to the class—man. Besides we have seen already that for the purpose of scientific investigation the world must be divided into small departments and these departments into smaller and smaller ones. Thus scientific investigation including induction depends on and presupposes classification. So "it is often highly important, if not essential, to arrange these phenomena in groups, as well as to determine the order in which these groups themselves shall be arranged. Hence the importance of laying down correct rules for classification in a System of Inductive Logic." (Fowler's *Inductive Logic*, p. 47 .

But we shuld notice in this connection that classification rests on the principle of co-existence whereas Induction rests on the principle of causation and the uniformity of nature. In classification we view things as stationary while in induction we consider the changes of these things and their laws

and causes. Hence classification views nature in its statical object while induction views nature in its dynamic aspect.

12. *Classification, Generalisation, and Conception*. These are all allied processes. Conception is a process by which we form a mental image of a number of individual objects with the help of their common esential attributes which constitute the connotation of the mental image. Whereas in classification we arrange objects under groups according to their important points of resemblance. Thus in classification importance is placed on the denotation of the class formed. Generalisation is also based upon similarity or identity of nature or the conditions of the objects generalised. Classification supposes the idea of a class, i. e., a concept and so does generalisation. All these processes again involve analysis, comparison and abstraction and are ultimately based upon the essential attributes of individual objects formed into a class. It becomes impossible to have the one without the other.

In conception and classification we examine only a small number of individuals, yet the concept and the class formed comprehend practically an infinite number of objects. This becomes so on account of the generalisation involved in them. *Generalisation* is a process by which a truth found in some cases is extended to a class of cases existing in the past, present and future. Therefore without the supposition of a class and so without the supposition of the idea of a class or concept no generalisation is possible.

In our experience we come across individuals only. By analysis and comparison we detect their common essential attributes. In order to make conception, classification and generalisation possible these common essential attributes should be separated from the individual peculiarities of these objects. This process of separation is called by the name *abstraction*. Thus conception, classification and generalisation all depend on abstraction. So these processes are all inter connected.

13. *The Uses of Classification.* The first use of classification is the better understanding of the facts of nature. An object presented to our experience is understood when we find out its similarity and difference with things that have been already known or in other words when we draw a relation between it and the already known objects i.e, when we bring it under a class. As long as we fail to do this our mind remains in a puzzled state and as soon as we refer an object to a known class we feel a great deal of relief. In short classification explains the facts of nature,

The second use of classification is to aid the memory, i. e., in helping us to remember the facts of our experience. It is very difficult to remember objects individually distinct and separate. The more scientifically the objects are classified the stronger and more numerous becomes the bond of association and the less becomes its possibility of being forgotten. Classification aiding memory gives us control over our ideas and experience.

Classification also suggests hypothesis and as such helps us in drawing inductive inference. We know that things similar in some respects are likely to behave similarly in others. When a new metal is discovered we at once say that if it is heated it will expand on the ground that other members of the class, metal, expand when they are heated,

14. *The Rules or the Method of Classification.* We should follow the following rules in classifying any multitude of given objects. In fact these rules indicate the method we should follow in classifying objects. Sometimes they are wrongly called the conditions of classification. By the conditions of classification we mean the rules which we should follow in testing a classification or the rules which every classification should follow in order to be valid.

(1) *Place together in groups those things that have in common the nost numerous and the most essential attributes.* This is said to be the **golden rule** of classification.

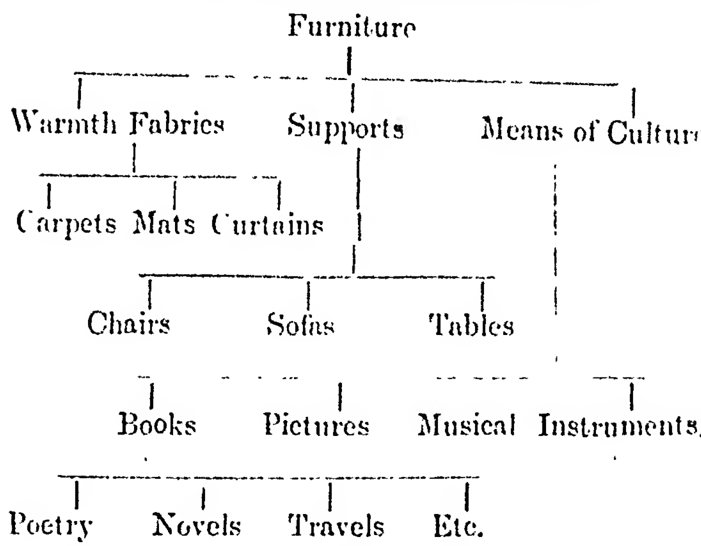
(2) *Connect those groups that have the greater resemblance, and separate those that have the greater difference.*

(3) *Graduate the classification upwards in a series so as to form higher and wider classes till the summum genus is reached.*

(4) *The proximity of the sub-classes should be determined by the degree of their likeness and affinity, and the distance by their difference and variation.*

We have already seen that according to Mill and Jevons we should first of all define the class that we are going to form and then bring within it those objects that possess the attributes implied by the definition. But according to Whewell in order to classify individuals we should first of all get hold of a type and then form a class round this type. We alrhaveeady seen that the selection of type is poss ibleonly when the definition is known and so classification by type supposes classification by definition. Hence we conclude that scientific classification should be grounded on definition and this has been embodied in the first rule of classification.

15. Illustrations of classification.



Here Furniture may be called a Kingdom, warmth fabrics, Supports and Means of Culture may be called Genus: Carpets, mats, curtains, chairs, sofas, books etc are the species, while Poetry, Novels, etc., are the varieties of the species, Book.

Illustration of Classification from C. Read's Logic explaining various technical terms such as Kingdom, Sub-kingdom, etc.

Kingdom : Animal Kingdom

Sub-Kingdom : Vertebrates | Invertebrates

Sauropsida | Ichthyopsida

Class : Mammals | Birds | Reptiles | Amphibia | Fishes

Sub-Class : Placental | Implacental

Division : Monodelphia | Dide phia | Ornithodelphia

Order : Quadrumana | Rodentia | Carnivora | Ungulata | Caetacea etc.

Section : (Family) Pinnigrada (Seals etc) | Plantigrada (Bears, etc.) | Digitigrada

Genus : Mustelidae (Weasels,etc) | Viverridae (Civets, etc.) | Hyaenidae | Canidae | Felidae

Species : Lion | Tiger | Leopard | Puma | Lynx | Cat, etc.

Variety : African | Syrian | Cave-lion (extinct)

Thus we have the following classes in order (1) Kingdom, (2) Sub-kingdom, (3) Class, (4) Sub-class, (5) Division, (6) Order, 7 Section or Family, (8) Genus and (9) Species. To this may be added (10) Variety which represents not a new class but the different forms of a class technically called Species. It should be noticed that in this classification Genus and Species are fixed while in Formal Logic any class may be genus in relation to its subclasses and may be a species in relation to the higher class containing it.

16. **How to test Classification** In order to test a given classification we should apply the rules by means of which division is tested. We have considered these rules in connection with Division in the Text-book of Deductive Logic at page 75. In logic we are more concerned with the rules for testing classification than with the method of classification which is the subject matter of the applied logic or the positive science. These rules for testing the correctness of classification are also called the conditions of classification. The fallacies of classification are identical with the fallacies of Division.

17. **Limits of Classification.** As classification is a scientific statement of our knowledge of objects. so things of which we hardly know any thing definitely cannot be classified. So the limits of knowledge are the limits of classification. Again we have seen that scientific classification is grounded on definition and so when the definition of the class is not known we cannot form that class. So the

limits of definition are the limits of classification. From these it follows that (1) the *marginal instances* cannot be classified. By the marginal instances we mean those objects which partake of the characteristics of two classes but do not definitely belong to any one of them. Hence they cannot be brought under any one of them. Sponges partake of the characteristics of both plants and animals but do not definitely belong to any one of them. Similarly jelly pertakes of the characteristics of both solid and liquid but do dot belong to any one of them definitely. So are the idiots who are neither men nor animals though they resemble both these classes. These are called marginal instances. To remove the difficulty caused by the marginal instances the classification by type is suggested. (2) Composite objects whose components are always varying such as granite cannot be classified (3) Facts and phenomena which vary from man to man and even in the same man from time to time cannot be classified. Tastes, fashions, whims, etc., belong to this class (4) Objects whose characters cannot be satisfactorily ascertained cannot be classified. (5) Things which are unique in nature cannot be classified because in classification we are required to detect the points of resemblances which unique objects cannot possess, Our elementary experiences such as colour, taste, smell etc, cannot be classified for this reason. (6) There cannot be any class higher than the Summum Genus and so it cannot be classified.

18. Exercises.

1. How and why do we classify objects ?

2. Explain the different forms of Classification.

3. Show how Classification has been modified by Evolution.

4. Explain the significance of Evolution and Natural kinds. Which one seems to be acceptable to you ?

5. How should we test Classification ? Is there any distinction between the rules of Classification and its conditions ?

6. Explain whether we should classify by type or by definition. Explain in this connexion what you mean by type.

7. Explain what you understand by Classification by Series and Index Classification.

8. Bring out the relation between Classification and Induction. Is it in any way related to Conception and Abstraction ?

9. What is meant by a Natural Kind or Class ? Give an account of Natural Classification explaining what is meant by essential or fundamental characters as bases of Classification. 'A class is nothing but the objects contained under it'—examine this statement of Mill, showing whether it is correct or not.

10 Explain the nature of Classification and Division showing how they are related to each other. Point out the principal errors incidental to each, giving examples.

11. Explain the sense of the terms—family, kingdom, species, variety, order, and genus as used in classification, and show their respective places in the scale of natural classification, giving examples of each.

12. Explain the nature and use of Classification. How does it differ from Logical Division ? Distinguish Natural Classification from Artificial Classification, and give example of each.

13. Distinguish between Division and Classification. Is Classification based on Type or Definition ?

14. What is Natural Classification ? Is a Natural Group determined by a Type or by a Definition ? Discuss the question.

15. What is the point at issue between Mill and Whewell regarding the method of Classification ? Which of them do you think to be correct and why ?

16. Explain Classification, natural and artificial. Show that all classification is, in a sense, artificial.

17. Explain Natural and Artificial Classification, Classification by Definition, Classification by Type, and Classification by Series.

18. Explain the distinction between Natural and Artificial Classification. How far is the distinction tenable ? State and illustrate the principal rules for the right conduct of scientific Classification.

CHAPTER XIV.

Material or Inductive Definition.

1. Nature of Material or Inductive Definition. We have seen already in our *Textbook of Deductive Logic* that Definition is a statement of the entire connotation of a term in a clear unambiguous language. Now in Formal Logic we assume that all general terms have fixed connotation and in defining them formally we are required to state this assumed connotation in a clear unambiguous language. Hence formal definition is *analytic* in nature. But in material or Inductive Logic we are not entitled to assume that terms have fixed connotation—we are, on the contrary, required to find out their connotation by observation, analysis, comparison, abstraction, and generalisation. Hence material definition is *synthetic* in nature. From this it follows that inductive definition involves two factors, viz., the process by means of which the connotation of a term or class is found out, and the statement of this connotation in a clear unambiguous language.

In finding out the connotation of a term it is physically impossible for us to examine the practically infinite number of objects denoted by the term. Hence we can examine only a handful of objects denoted by the term, and so we have to find out the connotation of the term by examining this small number of objects. It is by means of generalisation

which is a form of inference we maintain that the common essential attributes detected by us are possessed by all the individuals denoted by the term whether examined or unexamined by us. Hence material definition is grounded on observation, analysis, and generalisation which are the fundamental factors of inductive reasoning. Besides the activities or doings causation) of things are determined by their essential attributes, and we come to understand these essential attributes of things by examining their doings. Thus being and doing are interrelated. Induction is concerned with the doings of things, and definition is concerned with their beings. So definition is closely associated with induction and like classification it is treated as a process subsidiary to induction.

We have found already that a general name in its denotative aspect implies classification and in its connotative aspect implies definition and both the processes are based on inference. Definition is also a compendious form of Explanation and involves assimilation and discrimination. The essential features of definition can be gathered from the following:-

(1) *Classes or general terms alone can be defined*. Individuals can be described but cannot be defined, because individuality implies a complex of practically an infinite number' of attributes each one of which is an essential factor of individuality. The omission of any one of them will destroy the individuality and will thereby destroy the purpose of definition.

(2) *Abstract terms not indicating elementary attributes can be more easily defined than concrete terms* because such terms are formed by the synthesis of attributes abstracted from concrete things or by the elimination of some of the attributes of concrete things which are found to be variable. But abstract terms admit of formal definition. Attributives, i. e, adjectives and participles can hardly be defined because in defining such a term we are compelled to state in the definition the abstract term corresponding to the attributive and as such the definition of an attributive is bound to be circular in nature,

(3) In the definition we are required to state only the fundamental or essential qualities of the term to be defined ; so *accident and proprium must be rigidly excluded from the definition.*

2. **Material Conditions and Rules of Definition.** In defining a term materially we have to ascertain its connotation and thereby show its relation to the world system of objects and ideas. In other words in order to define a term we are required to classify it.

Now in order to achieve this end we should follow the following rules :-

(1) We should examine a sufficient number of individuals forming the class to be defined as well as a number of individuals belonging to the opposite class with a view to ascertain the points of similarity and difference (differentia) indicated by the class

defined. The examination of the individuals belonging to the opposite class makes the detection of the points of similarity and difference (differentia) considerably easier, e.g., we detect very easily the differentia of man, viz., rationality, when side by side with man we examine dogs and other brutes. This method of examining the individuals of the class to be defined along with the individuals belonging to the contrary class has been called by Bain the *positive and the negative method of definition.* The number of individuals belonging to a class being immensely large we should try our best to get hold of the representative varieties of that class and examine them carefully, e. g., in order to define the class, dog, we should examine the different varieties of dogs found all over the world.

(2) Then by means of analysis, comparison, abstraction, and generalisation we should detect those attributes which are common and at the same time essential. By the fundamental attribute of a class we mean an attribute which determines the very nature of the class and without which it cannot exist. It also determines a host of other attributes possessed by the members of that class.

(3) After the detection of the fundamental attributes we should state them in a clear unambiguous language taking special care not to include within this statement any other attribute. This statement is the material definition of the class defined. From this it follows that in defining a class materially we should take into account the

most important and the most numerous points of community among the objects constituting the class to be defined. This is called the *the golden rule of definition as well as of classification.*

(4) Lastly in discovering the fundamental attributes we should be guided by scientific knowledge and not by superficial or popular knowledge otherwise our definition will not be stable and the detected attributes will not be fundamental. We should use all the possible scientific instruments and devices for making the analysis and detecting the fundamental attributes.

But much difficulty is felt in following this method of definition on account of two things, viz., (i) the number of individuals that we are required to examine is so immensely large that we can hardly manage them. The variety of these individuals is also unmanagably great. Even the representative instances which we are required to examine are so very great that we can hardly exhaust them. (ii) The second difficulty is created by the *marginal instances* also called *frontier instances* which partake of the characteristics of two classes but do not definitely belong to either of them. But this difficulty can be removed by forming special classes with these marginal instances and rigidly excluding them from the class defined.

To get rid of these difficulties *Definition by Type* has been suggested as a remedy. Such a definition consists in first of all finding the type of the class which we are required to define and then

stating that all things resembling that type should be called by the name of the class of which it is the type (Vide our *Textbook of Deductive Logic*, p. 99). We have seen already that we cannot find out the type of a class without knowing the definition of that class and without taking its help. Hence the Definition by Type does not give us any advantage. Popular definitions are generally Definitions by Type. But in such definitions any and every member is treated as the type. But such a type as well as the definition based on it requires constant modification in the light of fresh experience. If a flat nosed, thick lipped man be treated as the typical man then the white skinned Europeans can hardly be treated as man. This shows the worthlessness of the popular definition by type as a kind of definition. Besides a type seems to suggest that it is comparatively the most permanent member of the class, but experience shows that the most developed ones perish more quickly than the other members of the class. Definition is really a very difficult process, for it is possible only when we have acquired a thorough knowledge of the class to be defined. But such a thorough knowledge is practically impossible for us to attain. Hence the logical definition presents us with an ideal which we approach no doubt but fail to realise inspite of our best efforts. Carveth Read admits that "the statement of a definition approximate, is an honest confession that both the definition and classification are (like a provisional hypothesis) merely the best

account we can give of the matter according to our present knowledge" (*Logic* p. 326).

4. Exercises

1. Distinguish between Formal and Material Definition.

2 State and explain the method of Inductive Definition.

3. Explain definition by Type. Is it acceptable ?

4. Explain the nature of Material Definition. Does it involve generalisation ?

5. What are the difficulties of Material Definition ? Show how they are to be met giving concrete examples.

5. "The process of determining a definition is inseparable from classification." Explain this and discuss the difficulties and limits of definition.

CHAPTER XV

Terminology and Nomenclature.

1. **Nomenclature.** By Nomenclature we mean a system of the names of all the *classes* of objects considered by the different sciences. In the natural sciences such as Botany Zoology, Geology, etc, after examining the particular objects we arrange them into various groups and these again into higher groups, i.e., we classify the objects. By Nomenclature we give a name to each of these groups or classes. Thus classification ends with naming. The fundamental principle followed in scientific nomenclature is that our names should be *significant* and at the same time *elegant*, i.e, they should convey the essential part of the meaning with the least effort. These names also should have fixed precise meaning.

2, **Terminology.** By Terminology we mean a science which describes and defines the things that constitute the classes designated by Nomenclature as well as the parts of those things and their actions, relations and attributes. Thus Terminology supplies (1) a name for every integral part of an object, e. g., hand, head, heart, etc., (ii) a name for every metaphysical part of an object and for their degrees and modes, e. g., shape, colour, taste, smell, weight, etc., (3) names for all kinds of processes and activities experienced such as causation, integration, attention,

association, etc, (C. Read), and a name for every kind of relation existing in the world. In Terminology also our terms or names should be *significant* and *elegant*. Their meaning must be also precise and fixed.

3. **Popular Names.** The popular use of terms is generally vague and uncertain because ordinary people do not like to take the trouble of sifting the meaning of terms and of coining new terms to express new ideas and the varieties of the same idea. Altered circumstances also modify the meaning of our terms to a very considerable extent. For this reason science tries to avoid the popular names and coin new names and rigidly fix their meaning by defining them. Hence the scientific use of terms is precise and systematic.

In coining names of classes science follows the method of double naming technically called the **Binary Method.** It consists in coining a name of two parts of which one indicates the genus and the other indicates the special name for the species, the name of which is being formed, e.g., Felis-Leo (Lion). Felis-Tigris (tiger) ; Ferrus Oxide, Ferrus Sulphate, etc.

There are two methods by means of which the meaning of words is changed, viz., the process of generalisation and the process of specialisation.

The *process of generalisation* consists of extending a name meaning a particular thing to a class of things of similar nature, e.g., *oil* originally meant olive oil but on account of generalisation

it now means any oily substance such as castor oil, kerosin oil, mustard oil etc.

The *process of specialisation* consists of narrowing down the scope of the application of a name, e g., *fowl* originally meant any kind of bird, but on account of specialisation it now ordinarily means cock and hen. Similarly *wit* which originally meant any intelligent person now means a person who is able to make a fun.

The process of generalisation and specialisation depends on the following psychological laws of association :—

(a) *The law of similarity* e.g., *light* which means a natural phenomena is used for knowledge because light removes physical darkness while knowledge removes mental darkness.

(b) *The law of contiguity* i.e., contiguous things become so associated that the name of one of them is applied to the other in course of time, e.g., *crown* is used for royalty and *horse* for cavalry, *turf* for racing.

On account of the formation of new words by means of composition, i.e., by combining old words and thereby forming new words the meaning of the old words are modified, e.g., log book, man-of-war, up-platform, down train. Similarly by the *transitive application of words* the meaning of words become wholly changed. If we find that A is similar to B, B to C, C to D, D to E, and E to F, the name of A is sometimes extended to F though there might not be any similarity between

A and F. Such a transition in the meanings of words is called the transitive application of words. *Letters* which actually mean alphabets have been extended by this process to the postal goods. Similarly *sleeper* has come to mean the wooden blocks on which the rail road rests.

For a systematic accurate information about this subject we should go to philology. In Logic we are required to use term in a definite fixed sense and so Logic does not allow any change in the significance of terms If we use a term in one sense we must use it in exactly the same sense without any variation whatsoever. Terminology and Nomenclature are essentially needed not only in Logic but also in every other science because we cannot satisfactorily express our ideas without the help of terms and names and we cannot record our knowledge and the truths discovered by us without the help of terms and names. Welton says, "No classification could long remain fixed without a corresponding Nomenclature and every good Nomenclature involves a good system of classification." More correctly classification which is a mental process becomes absolutely impossible without Nomenclature.

4. **Language and Thought**. Being a social creature man is obliged to mix freely with his fellow creatures and exchange his thought with them. But this can be done only with the help of language. So language is essentially needed for communicating our thought to our fellow creatures. For the forma-

tion of complex thought of the higher kind also we need language. Abstract ideas can be expressed only with the help of language. Language helps our memory and helps us to some extent in retaining our experiences in mind for some considerable time in some fixed groups and relations. Language makes our ideas precise and helps us in proceeding from one idea to another very easily. It is language which gives permanence to our experiences and discoveries and enables us to profit by the experience of those who have gone before us. The accumulated experience of mankind being recorded in language has enabled mankind to establish the kingdom of man and to bring into existence the modern culture and civilisation. Each brute has to learn every thing from the very beginning and cannot take the help of the experience of their ancestors on account of their ignorance of a systematic language. Thought and language are connected in such a fashion that one of them can hardly exist apart from the other, and the development of one of them depends on that of the other. The cultural development of a nation considerably depends on the language of the nation. For this reason much attention should be paid for the development of our vernaculars.

Question may arise as to whether thinking is possible without language. But this problem is more psychological than logical. We may say only this much here that only rudimentary thinking is possible without language. "We can often

remember with great vividness persons, things, landscapes, changes, and actions of persons or things without the aid of language and may form judgments or inference about them, but without language it is impossible for us to form general notions or to have judgments and inferences about them." Even generic images help us very little in these matters.

The unconscious region of our mind discovered by the modern psychologists contains thinking and reasoning without the help of language. But we remain totally ignorant of such a kind of thinking unless we are able to study our dreams, errors, whims, and idiosyncracies, and divine their meaning. Such thinking falls completely outside the scope of Logic.

5. Exercises.

1. Explain Terminology and Nomenclature. What are their uses? Why are they considered in Logic?
2. Explain the distinction between popular and scientific names.
3. Show how the significance of names is changed.
4. What are the requisites of scientific language?
5. Explain the relation between thought and language. Can there be any thinking without the help of language?
6. Fully explain and illustrate the use of Nomenclature and Terminology. Exhibit the relation of Nomenclature to Definition and Classification.

CHAPTER XVI.

Laws of Nature.

1. **Law and a Law of Nature.** The word, *law*, literally means that which is laid down. In Politics in which this word was originally used, it means that which is authoritatively laid down as a command by a political superior to those who are politically inferior with a view that it shall be uniformly obeyed. In case of violation these laws are enforced by punishment. The intention of these laws is the good of the state, society, or the subjects, or the good of the human community. Thus a political law implies (1) a law giver, (2) subjects, (3) a reference to time and place (4) liability to change, violation, modification and suspension, (5) beneficial purpose and (6) a desire to have uniformity in the conduct of the subjects. From Politics, the word, law, has been extended to literature and science where it has been identified with any uniformity whatsoever.

By a **law of nature** we mean any uniformity that can be observed in nature. Things, beings, and forces of nature behave in some uniform way and thereby give rise to several laws of nature. The laws of physics and chemistry can be cited as illustration. The peculiarity of a law of nature is that it has neither any beginning nor any end and that it can neither be changed, suspended nor violated,

whereas a political or human law has a beginning and can be changed, suspended or violated The law of gravitation is a law of nature and the excise laws prohibiting the sale of liquor without a license is a political or human law.

2. **Distinction between different kinds of Laws.** A law of the State, i. e., a political law has a beginning and rests upon the wish of a being having political authority and it can be changed, suspended, modified, abolished, and violated. It is generally negative in character and is enforced by penalty and sometimes by reward, e. g., you shall not commit murder or theft. Political laws are not the same everywhere and in every time.

The laws of nature are not man-made laws though they are discovered and interpreted by human beings. They have neither any beginning nor any end. They cannot be changed, modified, suspended or violated. The facts and phenomena of the world are compelled to follow them. These laws can be counteracted, e. g., the law of gravity which attracts the punkha downwards is counteracted by the ropes and pegs with which the punkha i hung. But at no time of the counteraction the la of nature ceases to operate and so when the counter acting forces are withdrawn the punkha is found t fall to the ground and the effect of the law of gravit becomes manifest. The laws of nature do not depen on the wish of any body but are grounded on th eternal principles of nature. They are generall positive in character ;and can be expressed b

hypothetical propositions,e.g., "the path of a projectile is a parabola" can be put in the hypothetical form : If a rigid body be projected it will move in a parabola. Similarly "If a body be heated its volume will expand" is the hypothetical version of the natural law "Heat expands the volume of material bodies". The laws of nature are everywhere and always the same. The psychological laws are natural. They are positive and eternal. They cannot be suspended, changed, modified, violated or abolished, e. g.. the intensity of sensation increases in arithmetical progression as the stimulus increases in geometrical progression.

A law of Logic is *normative* in character, i. e. we ought to follow it in our argument. It can be violated at the sacrifice of our reasoning. But it is not enjoined by any political penalty. Like the law of nature it is eternal in character and does not depend on the wish of any body but it can be violated. The logical laws, the ethical laws, and the laws of hygiene place before us some ideal which is different from what actually takes place in nature, while the positive sciences tell us how the facts and phenomena of this world actually behave. Hence the laws of Logic, Ethics, and Hygiene are concerned with *ought*, while the positive sciences are concerued with *is*.

3. **Classification of Laws.** We classify laws according to their degree of generality or the scope of their application. Some laws are called *higher* because they are more general than others, while

some laws are called *lower* because they are less general than others. According to generality there are three kinds of laws, (1) the axioms, (2) the primary laws and (3) the secondary laws.

(1) **Axioms**. These are the laws of the highest degree of generality. They are in fact universal and self-evident. These are assumed by the different sciences. Inference is grounded on them. The laws of identity, non-contradiction and excluded middle as well as the axioms of mathematics may be cited as examples.

(2) **The Primary or Ultimate Laws.** Next in order of generality we have the primary or ultimate laws. These are the highest generalisations made by the different sciences, e. g., the law of gravitation in Astronomy, the law of relativity in Psychology, the law of definite proportion in Chemistry. These are generally based on uncontradicted evidence and are sometimes established by the method of hypothesis. These assume the axioms and are therefore less general than the latter. The particular facts and phenomena observed by us in a department of nature are at first generalised into minor laws; these minor laws are generalised into higher and higher laws till the highest law is arrived at. This highest law of a particular science governing the facts and phenomena of a department of nature is called the ultimate law of that science. These are pre-eminently the Laws of Nature according to Bain.

(3) **The Secondary Laws.** Next in order of

generality we have the Secondary Laws. These are the laws that are arrived at by the generalisation of particular facts of our experience or deduced from the primary laws and proved by them. These have been called by Bacon *media axiomata* or middle axioms or intermediate generalities. According to him these must be inferred by generalisation from a particular group of facts experienced by us and these serve as an intermediate step between facts, and the primary laws. So according to him these laws are not deduced from the primary laws nor are they established by the process of deduction. But there are some secondary laws which are established by deducing them from the primary laws. Hence the scope of the secondary laws is greater than that of the middle axioms of Bacon. These secondary laws are of great practical value.

The Secondary Laws are classified in various ways :-

(i) **Derivative and Empirical Laws.** The Secondary laws are said to be Derivative when they are deduced from the primary laws of nature, e. g., the law of falling bodies and the law of the rise of water in the pump are derivative in nature as they are deduced from the primary laws. The secondary laws are said to be *empirical* when they are based on uncontradicted experience and are inferred by generalisation from experience. These empirical laws are applicable to adjacent cases; in other words these empirical laws have a limited application, i e., they are not universal. They hold

good ordinarily only in the neighbourhood of the facts and phenomena from which the laws are derived. The empirical laws are mainly based on the Method of Agreement. Secondary laws based on the Method of Difference are sometimes called Derivative as they are derived from the law of causation and the uniformity of nature. The Method of Difference we know establishes a relation of causation and a law establishsd by the Method of Difference may be said to be deduced from the Law of Causation which is a primary law. Hence there is justification for calling the laws established by the Method of Difference derivative. Yet the laws establisl ed by the Method of Difference are sometimes called empirical on the ground of our enquiry being from facts to laws, i. e., inductive. Mosquito causes malaria and quinine cures it; poison kills life, clapping produces sound should be treated as derivative laws because they are grounded on the Law of Causation, yet sometimes they are called empirical. All crows are black; snow is white, milk is white, scarlet flowers are odourless are all empirical laws because they are grounded on uncontradicted experience. Some secondary laws are at first arrived at empirically but later on they become changed into derivative laws by deducing them from the primary laws. The law of tides was at first an empirical law but it has been changed into a derivative law by deducing it from the law of gravitation which is a primary law. An empirirical law may be described as a law whose *why* or

reason or cause has not yet been ascertained, while a derivative law may be described as a law whose *why*, reason or cause has been found out.

(ii) **Invariable and Approximate Secondary Laws :** Secondary laws are said to be *invariable* when they govern an entire class of facts without any exception, e. g., All men are mortal. Secondary laws are said to be *approximate* when they govern only a part of a class of facts and admit of exception, e. g., Most metals are solid ; Industrious people are successful.

(iii) **Secondary Laws of Succession and Co-existence :** The Secondary Laws are again divided into Laws of Succession and Laws of Co-existence.

The Secondary *Laws of Succession* are again classified into the following :—

(a) Laws of direct causation, e. g, Fire burns ; Opium produces sleep ; Poison destroys life.

(b) Laws of remote causation, e. g., No cat, no clover ; No rat no plague ; No mosquito no malaria.

(c) Laws of succession existing between some joint effects : Rains follow the summer in Bihar ; Night follows the day ; Report of the gun follows a flash of light.

The secondary *Laws of Co-existence* are classified into the following :—

(a) Geometrical co-existences, e. g., The three angles of a triangle are together equal to two right angles.

(b) Co-existences among the universal proper-

ties of concrete things, e. g., gravity co-exists with inertia.

(c) Co-existence of properties in natural kinds, e. g., animality and rationality co-exist in human beings ; a number of qualities are found to co-exist in a particular class of trees.

(d) Co-existences due to causation, e. g., the co-existence of plants in a garden ; the co-existence of houses in a town ; the co-existence of light and heat in the rays of the sun.

(e) Certain unaccountable co-existences, e. g., blackness in crows ; whiteness in milk and snow ; deafness in tom-cats with blue eyes ; absence of fragrance in scarlet flowers (C. Read),

4. **Classification of Empirical Laws** : Empirical Laws can be at first divided into *invariable* and *approximate* just like the secondary laws. Secondly we can divide empirical laws into *Laws of succession* and *Laws of co-existence.* The law that the use of milled rice and impure mustard oil is followed by beri-beri is an empirical law of succession, while the law that scarlet flowers are odourless is an empirical law of co-existence There are some empirical laws which are believed to be grounded on causation but as yet their causal basis has not been discovered. Such is the case with the various laws of weather. On the other hand there are some empirical laws whose causal basis has been discovered and thereby the empirical laws have been changed into derivative laws. Such is the case with the law of tides, the cycle of the seasons.

There are some empirical laws whose causal basis cannot be expected to be found out. Such is the case with the empirical laws : Milk is white ; Tom-cats with blue eyes are deaf. In classifying empirical laws great difficulty is felt on account of the fact that the laws which are at present empirical in nature may be changed in course of time into derivative laws.

5. **The World as a System of Laws.** The word, 'system' implies a plurality of factors inter-connected with one another, each one of the factors having a separate function of its own, and all the factors jointly try to realise some common goal ; and if there be any disturbance in the working of any one of the factors the working of the system will be disorganised and thereby all the factors will suffer. The human body is a system because it has a number of inter-connected organs and each one of these organs has a separate function of its own and all the organs jointly try to realise some common goal namely the preservation and perfection of the body. Similarly a watch is a system because it has a number of wheels and axles all inter-connected with one another and each one of them has a separate function of its own and all of them jointly try to realise one common goal, i. e., to move the minute and the hour hands at a regular speed.

Now when we say that the *world is a system of laws* we mean that the particular instances of things, beings, and happenings presented to our

experience are not so many isolated uncommon facts and phenomena,—they are all inter-connected with one another and are governed by some law or laws and are jointly trying to realise some common good or purpose. There is nothing in this world which is not governed by any law because all the facts and phenomena of this world are the manifestations of laws and are governed by them. The expression 'the world is a system of laws' also means that the laws operating in this world are infinite is number and that they can be generalised into higher and higher laws and ultimately into the highest possible law and that all these laws are working in a harmonious way there being an inherent relation and a common nature throughout these laws with a view to realise some common purpose or good. Hence the conception of the world as a system of laws leaves no room for miracle or chance. The apparently uncommon phenomena such as earthquakes, storms, cyclones, war and the like are governed by laws and have functions to perform for the realisation fo the world's highest good.

The aim of Inductive Logic is to show that the particular instances presented to observation and experiment can be brought under laws which again can be generalised into higher and higher laws and ultimately into the highest possible law. The aim of Deductive Logic is to show that all the particular instances that we come accross in our experience follow from the most fundamental and ultimate law of nature. Though we have not attained this position

either in Logic or in any other science yet we have got sufficient data to take for granted that the world is a system of laws and we hope that with the increase of knowledge and the progress of science this truth will be more convincingly established. Thus it follows that the aim of Logic is to show that the world in which we live, move, and have our being is a system of laws and not a conglomeration of chance facts and phenomena.

6. Exercises.

1. Explain the significance of Law in Politics, Science, and Logic.

2. Distinguish between a positive and a normative law. What kind of law is a law of the State ?

3. Explain what you mean by a Law of Nature. Can such a law be modified ? Explain the nature of the Laws of Psychology.

4. Explain how Laws are classified. Illustrate the different kinds of Laws.

5. Explain what you understand by the World as a system of Laws. Can there be any miracle ?

6. Explain what you understand by Laws of Nature. How are they classified ? What precisely is meant by an Empirical Law ?

7. What is a Law of Nature ? How does it differ from an empirical law ? Explain the use for science of the discovery of empirical laws.

8. What is a Law ? Distinguish between a Law of the State, a Law of Nature, and a Logical Law

illustrating your meaning by examples. Classify the Laws of Nature, explaining your classification.

9. Explain Primary, Secondary and Empirical Laws,

10. Why should Laws of Nature be expressed as tendencies ?

11. Do the Laws of Nature rest on any primary assumption ? How are such laws established ? Explain and illustrate their different forms.

12. Mention the different Methods of classifying Secondary laws that have been adopted.

13. What do you understand by a Law of Nature ? Distinguish between Primary and Secondary Law, and explain and illustrate the different kinds of the latter. What do you understand by the expression that the World is a system of Laws ?

14. What are Laws of Nature ? Define and exemplify Ultimate, Secondary, Derivative and Empirical Laws, showing their relation to one another. To which class will those laws belong which are founded on the Method of Agreement ? Give your reasons with examples.

CHAPTER XVII.

Inductive Fallacies.

1. The Nature of Inductive Fallacies. By the Inductive fallacies we mean all those mistakes which we commit in connection with inductive reasoning and the processes subsidiary to Induction, such as Observation and Experiment, Explanation, Classification, etc. The material fallacies of Deduction are generally treated along with the inductive fallacies but it is more reasonable to treat them along with the Deductive fallacies becausein advancing such an argument our intention is to prove a proposition deductively and our misconception about the nature of the deductive proof is responsible for such a fallacy.

The Inductive fallacies cannot be properly classified because it is very difficult to have a principle of classification on account of the interrelation that exists between the different topics of Induction, and also because the number of ways in which one can commit a mistake is so very large that it is practically impossible to enumerate them and bring them under distinct classes. These mistakes depend greatly on the personal equations of the individual beings which vary from person to person and so cannot be brought under one class. Besides a particular inductive fallacy involves differnt kinds of

inductive fallacies, e. g., a fallacy of observation may give rise to all kinds of inductive fallacies. Hence it is not possible to have mutually exclusive classes of fallacies in Induction. But we can enumerate the principal kinds of fallacies relating to the different topics considered in Induction.

2. **Kinds of Inductive Fallacies.** Inductive fallacies may be divided into Inductive non-inferential Fallacies and Inductive inferential Fallacies. The principal forms of the Inductive non-inferential fallacies are the fallacies of Observation and Experiment, the fallacies of Explanation, Classification, and Definition. These have been already considered.

The principal forms of the Inductive inferential fallacies are (1) the fallacies relating to Causation (2) the fallacies due to the misapplication of the Methods, (3) the fallacies of Analogy, (4) the fallacies of Probable calculation, and (5) the fallacies of Illicit Generalisation or improper Induction.

All these fallacies excepting the first have been considered at their proper places. In this chapter we shall consider only the fallacies relating to Causation which are known as *Non causa pro causa.*

3. **The Fallacy of Non Causa pro Causa.** The Fallacy of *Non causa pro causa* consists in viewing as cause what is not a cause. If we establish a causal relation between A and x when there is no causal relation between them we commit the fallacy of *non causa pro causa.* There are three principal kinds of this fallacy, viz.,

(i) *The fallacy of viewing a case of co-existence as a case of causation*, e. g., it is a fallacy to view scarlet colour as the cause of the absence of odour in flowers, because scarlet colour is found to co-exist with this absence of odour. Similarly it is a fallacy to consider the possession of horns as the cause of ruminating. We have seen already that there is a relation of succession between a cause and its effect. So co-existing phenomena cannot be treated as cause and effect.

(ii) The Fallacy of *post hoc ergo propter hoc* The expression *post hoc ergo propter hoc* means after this, therefore, on account of this, i e., caused by this. In this fallacy a simple case of succession is viewed as a case of causation. But we know that a causal relation always implies not only succession but also invariability, unconditionality, and immediacy. Thus it is erroneous to view any and every case of succession as a case of causation.

This fallacy is a from of *non causa pro causa* because in it we establish a causal relation where there is no causal relation. We are very familiar with this fallacy in our every day life. In Sanskrit it is called *Kāka tāleea bat* which comes from the fallacious argument that the sitting of the crow is the cause of the falling of the palm. The following are the instances of this fallacy :-

(a) The north Bengal flood took place immediately after the eclipse of the sun and so the people argued that the eclipse of the sun was the cause of the flood.

(b) Napoleon was defeated after his Russian expedition and so historians concluded that his Russian expedition was the cause of his defeat. Similarly it is argued that the divorce of Josephine was the cause of his downfall because it began after the divorce.

(c) If a case of death, misfortune or failure at an examination takes place in a family after the marriage ceremony of a young man of that family then the bride is wrongly believed to be the cause of the death, misfortnne, and failure. Similarly it is a fallacy to believe that a person missed the train because he saw on his way to the station the face of a miserly person. Though such arguments are fallacious yet the lives of most of the people are being governed by such arguments. Such arguments and *argumentum ad baculum* will become in future more prevalent on account of the fact that many students and citizens fail to take interest in Logic and Philosophy and even reputed philosopheres are casting doubt on the logical method of enquiry.

(iii) *The fallacy of viewing a condition as the entire cause of a phenomenon.* We invariably argue that the cutting of the string of a picture is the cause of the falling of the picture because when the string is cut it invariably falls to the ground, though we know that there are other necessary conditions, viz.. gravity. As we do not know when the effect of gravity will be manifest and when the string will be cut B. Russel wants to describe all laws of nature as tendencies.

The following are also the forms of *non causa pro causa*:—

(i) We commit the fallacy of *non causa pro causa* when we assign a cause to a thing which is not a concrete events, as for instance we shall commit this fallacy if we say that the equality of the two arms of an isosceles triangle is the cause of the equality of the basal angles. Geometrical relations can have reasons but no causes.

(ii) *The fallacy of transcendent inference or transcendental fallacy.* The events happening in the universe have causes but if we proceed from the causes of these events to the cause of the universe as a whole we commit thia fallacy, i. e., we apply causation to a sphere which lies beyond its scope. The inductive inference of the first cause and its identification with God on inductive ground involves this transcendental fallacy.

(iii) We commit the fal'acy of *non causa pro causa* when two causally connected events are viewed as independent pheonmena. The prosperity of towns is determined by the presence of great navigable rivers. So we commit this fallacy if we maintain that it is a matter of chance that great rivers flow past great towns.

(iv) *We commit this fallacy when we treat a remote event as the true cause of a phenomenon*, e. g., Napoleon's Russian expedition is wrongly believed to be the cause of his defeat though there was a great interval of time between the two. It should be borne in mind that the cause is an immediate antecedent of an event.

(v) *We commit this fallacy when we treat co-effects as cause and effect.* We know that the flow tide and the ebb tide are produced by the attraction of the moon and the sun, and so we commit this fallacy if we view one of them as the cause of the other.

(vi) *We commit this fallacy when we overlook the negative conditions.* If we treat 212° F. H. as the cause of the boiling of water we shall commit this fallacy because here we overlook the fact that the pressure of the atmosphere must not be greater than that at the sea level.

(vii) *We commit this fallacy when we neglect the collocation* or establish causal relation between two phenomena which are quantitatively inadequate in relation to each other. For this reason it is a fallacy to treat the murder of the Crown Prince at Serajivo as the cause of the great European war.

(viii *This fallacy is also committed when we neglect the possibility of the plurality of causes* as when we admit the efficacy of the rod in the formation of character and intelligence.

This fallacy is often extended to the inaccurate and imperfect determination of the effect. When an irrelevant consequent or a variable consequent is viewed as the effect we are said to commit this fallacy of *non causa pro causa.* When a part of the effect is viewed as the total effect or a remote consequent is viewed as the effect we commit this fallacy. We also commit this fallacy when we treat the effect as the cause as when we treat sleepless-

ness as the cause of headache though as a matter of fact headache might be the real cause of sleeplessness. Similarly if we find that two phenomena are related in such a fashion that each one of them is capable of producing the other then we shall commit this fallacy if we treat any one of them as the cause of the other.

Thus the mutuality of cause and effect involves the fallacy of *non causa pro causa.* It is also a fallacy "to demand greater exactness in the estimate of causes or effects than a given subject admits of." The logical cause is an ideal cause and as such it can hardly be realised in non-mechanical sciences. Hence it will be a fallacy on our part to demand exact logical causal relations in non-mechanical sciences such as Biology, Psychology, Sociology and Politics. In these sciences we can have only approximate generalisations.

4. Exercises.

Hints : In examining an argument it should be, first of all, rigidly reduced to the logical form and then the nature of argument should be stated, i.e., its name should be given. Then the name of the fallacy, if any, should be given, and lastly the reasons for which the argument involves the fallacy should be clearly stated. In order to arrive at the central thought of an argument it should be carefully read several times.

1. Test the validity of the following arguments naming the fallacy, if any, and stating the reasons in each case :—

(a) The eating of mangoes is the cause of boils.

(b) The mind must be a function of the brain, since any serious injury to the brain is always followed by loss of consciousness.

(c) The flood was evidently due to the wrath of the goddess, since it began immediately after she had been slighted, and it subsided as soon as she was propitiated by sacrifices.

(d) A conjuror produces wonderful results by different tricks on different occasions, taking care to wave his wand each time, therefore, the waving of the wand is the cause of the wonderful results.

(e) The University is the Temple of Learning therefore Politics has no place in it.

2. Test the validity of the following arguments, naming the fallacy, if any, and stating reasons in each case :—

(a) The terror ceased immediately on the death of Robespierre ; therefore Robespierre was the cause of the terror.

(b) States that have grown outrageously luxurious have declined in power. Hence we conclude that luxury was the cause of their downfall.

(c) Wines cannot be injurious to health, for if it had been so the doctors would not have prescribed it.

(d) Women as a class have not hitherto been equal to men ; therefore, they are necessarily inferior to men.

(e) Education is clearly the source of all discontent, since the educated not getting suitable employment, are dissatisfied with their lot.

(f) Scarlet poppies, scarlet verbenas, the scarlet hawthorn, and honey-suckle are all odourless ; therefore we may conclude that all scarlet flowers are destitute of odour.

(g) It has been found that linnets when shut up and educated with singing larks—the skylark, woodlark or tit lark—will adhere entirely to the songs of these larks, instead of the natural song of the linnets We may infer therefore that birds learn to sing by imitation and their songs are no more innate than language in man.

(h) Vesalius, the founder of modern anatomy found that the human thigh bone was straight, and not curved, as Galen, the great authority on the subject for over a thousand years, had asserted. Sylvius replied that Galen must be right; that the bone was curved in its natural condition, but that the narrow trousers worn at the time had made it artificially straight.

(i) All bats are birds, for they have wings.

(j) Unfortunately all the men with whom I have been acquainted are selfish; how then can I resist the conclusion that the men are selfish?

(k) The anatomical resemblance between men and apes is marvellous, and from such resemblance we can safely conclude that men are descended from apes.

(l) My friend must be a genius, for he has many eccentricities, as all geniuses have.

(m) The Professor must be a very learned man, for his words are so big and hard that very few understand them.

(n) Green colour is found only in the surface region of plants. If one cuts across a living twig or into a cactus body, the green colour will be seen only in the outer part of the section. Hence the green colour of plants holds some necessary relation to light.

(o) Tyndall found that of twenty seven sterilised flasks containing infusion of organic matter, and opened in pure Alpine air, not one showed putrefaction; while of twenty three similar flasks,

opened in a hayloft, only two remained free from putrefaction after three days. He concluded that putrefaction is due to floating particles in the air.

(p) The non-co-operators should not boycott the University, for their leaders are educated men.

(q) The reforms have given a death blow to Bolshevism in India for the people ane now looking forward to a better state of things

(r) We should not mourn the death of eminent men, for by the law of the survival of the fittest, those that are still alive must be fitter and better than those that are gone.

(s) Oh, I should give the whole world for peace of mind for that is really valuab'e.

(t) I do not consult physicians, for those that do so also die.

(u) This man must be the thief, for he was in the room whence the article has been stolen and he came out as soon as I entered the room.

(v) How glad am I at your success which I really anticipated ! Is it not meet, therefore, that you should give me some reward ?

(w) What better explanation can you give of the fact that we can see through glass than that it is transparent.

(x) The great war was followed by an out break of epidemic disease, therefore, the war may be taken to be the cause of these diseases

(y) The number of deaths per annum in Calcutta is greater than in Nagpur. Therefore Calcutta is more unhealthy than Nagpur.

(z) One of the sailors rescued wore an amulet and this was no doubt the cause of his escape.

3. Examine the following arguments :—

(a) We should think it a sin and a shame if a great steamer dashing across the ocean were

not brought to a stop at a signal of distress from a mere smack...and yet a miner is entombed alive a painter falls from a scaffold, a brakeman is crushed in coupling cars, a merchant fails, falls ill and dies and organised society leaves widow and child to bitter want or degrading alms.

(b) During the retreat of the Ten Thousand a cutting north wind blew in the face of the soldiers. Sacrifices were offered to Boreas, and the severity of the wind immediately ceased, which seemed a proof of the god's causation.

(c) It is known by direct experiment that for any given degree of temperature, only limited amount of water can remain suspended as vapour, and this quantity grows less and less as the temperature diminishes. Therefore if there is already as much vapour suspended as the air will contain at its existing temperature, any lowering of the temperature will cause necessarily a portion of the vapour to be condensed as dew.

(d) He must be an excellent man in all respects, for I have been favourably impressed by his actions.

(e) Punishment must have some other and higher justification than the prevention of crime, for if punishments were only for the sake of examples it would be indifferent whether we punished the innocent or the guilty, since the punishment considered as an example is equally efficacious in either case.

(f) Moisture bedews a cold metal or stone when we breathe on it. The same appears on a glass of ice-water and on the inside of windows when sudden rain or hail chills the external air. Therefore when an object contracts dew it is colder than the surrounding air.

(g) With various kinds of polished metals no dew is deposited : but with various kinds of polished glass dew is deposited. Therefore the deposit of dew is affected by the kinds of substances exposed.

(h) We observe very frequently that very poor handwriting characterises the manuscripts of able men, while the best hand writing is frequent with those who do little mental work when compared with those whose penmanship is poor. We may, therefore, infer that poor penmanship is caused by the influence of severe mental labour.

(i) The mind must be a function of the brain, since any serious injury to the brain is followed by the loss of consciousness.

(j) Education is clearly the source of all discontent since the educated, not getting suitable employment are dissatisfied with their condition of life.

(k) The great famine in Ireland began in 1845, and reached its climax in 1848. During this time agrarian crime increased very rapidly until in 1848 it was more than three times as great as in 1845. It is evident from this that a close relation of cause and effect exists between famine and agrarian crime.

(l) So far as my experience goes, A has been invariably preceded by B, I therefore conclude that B is the cause of A.

(m) A habitual drunkard who studied hard for the army in his youth has got shattered nerves, therefore, the cause of his shattered nerves is his hard study in youth.

(n) Opium causes sleep because it has a soporific virtue.

(o) Since it is just to take interest, it is right to exact it from one's own father.

(p) We see the sun rise and set every day, therefore, the sun does actually rise and set.

(q) Unhealthiness in the parents is not the cause of unhealthiness in the children because many unhealthy persons have perfectly healthy children.

(r) The people of England are wealthy because they are industrious.

(s) As soon as I sat down to study this morning, the man in the adjoining room began to play on the harmonium. He must, therefore, be a very malicious person.

(t) This patent medicine must be very efficacious for all the testimonials speak of the marvellous cure effcted by it.

(u) We ought not to go to war, because it is wrong to shed blood.

(v) Water freezes at 32° F. Therefore it will freeze at 32° F at this time next year. Explain the logical character and the value of this.

(w) It is a common hypothesis in Bengal that railway embankments are causes (proximate or remote) of Malaria. What logical processes would be required to prove or refute this hypothesis ?

(x) Yesterday the smoke of the chimneys tended to sink downwards and it rained in the afternoon : Can any connexion be inferred from this ?

(y) When Crusoe saw the print of a bare foot on the sand shore he thought at once that savages had landed on his island. Give a logical analysis of Crusoe's thought.

(z) Induction as understood by Aristotle was reducible to this form :—A, B, C, etc., are mortal : A, B, C, etc., are men, therefore Men are mortal. Examine fully the reasoning here exhibiting its real form and value.

4. Test the following arguments :—

(a) You believe that Sirajuddaula took Calcutta from the English in 1756 : state on what grounds do you believe this proposition, and exhibit their logical character.

(b) It is a popular belief that there will be a change of weather at new moon. What logical process would be required to establish the validity of this belief ?

(c) A bell struck in vacuum gives no sound ; therefore sound must be a movement of the atmosphere. Exhibit the logical character of the resoning here.

(d) When beggars die there are no comet seen ; the heavens themselves blaze forth the death of princes. Characterize logically the grounds of this belief.

(e) Every man who has seen the world knows that nothing is so useless as a general maxim. Estimate this logically, pointing out what would be necessary for logically establishing this proposition.

(f) The more the number of pools of stagnant water in a district is reduced the rarer does the occurrence of malarial fever become. What conclusion can be drawn from the above statement ? State the reasoning implied in its full logical form, exhibiting the logical method applied in it and estimate the logical value of the inference.

(g) We think that as civilization increases poetry almost necessarily declines. Therefore though we fervently admir those great works of imagination which have appeared in dark ages, we do not admire them more because they have appeared in dark ages. State in logical form the reasoning involved and test it fully.

(h) "I have noticed", says Meng Tsien, "that in years of plenty many good actions are done, and in years of scarcity many bad actions are done, What is the inference evidently implied here ? Express it in simplest form, showing under which of the logical methods it falls, and indicate its logical value as inference.

(i) What kind of Logic is applied by (i) the engineer when he is designing a new bridge? the physician when he is prescribing a particular medicine to a patient, and (iii) the legislator when he is introducing a new law? Give reasons for your answer.

(j) 'An eclipse of the sum will occur when the moon intervenes between the earth and the sun'; 'an eclipse of the sun will occur when some great calamity is impending over mankind'. Examine the logical grounds and comparative validity of the above two propositions.

(k) All arsenic is poisonous; the substance before me is arsenic; it is, therefore, poisonous, Explain the logical process underlying your belief in the major premise, your belief in the minor premise and the conclusion drawn.

(l) Napoleon's Russian expedition was the cause of his dawnfall. Explain the fallacy here.

5. Explain the form of resoning, deductive or inductive or both, implied in the following propositions, indicating the premises or conclusion left unexpressed, and estimating the value of reasoning:—

(a) The sun will rise to-morrow morning.

(b) The lower auimals feel pain just as we do.

(e) He will die within a few hours; he has been bitten by a cobra.

(d) Intermittent fever is found only in places where there are marshes, even though they differ in every other respect.

(e) The factory commissioners say in their report: The past and present conditions of work in factories are undoubtedly calculated to cause physical deterioration; and we are struck with the marked absence of elderly men among the operatives.

6. Test the following :—

(a) The Evolution theory must be true, for it has support of able thinkers.

(b) England has a democratic government; therefore India should have a democratic government.

(c) Able men have generally bad hand-writing as is freqently found in men doing little mental work. Hence it is inferred that mental strain is the cause of poor penmanship.

(d) Malaria is found only in places where there are mosquitos. Mosquito, therefore, is the cause of malaria.

(e) Last year, the monsoon broke about the middle of June; this year, therefore, we will have monsoon the same time.

(f) Crows are black, because crows observed till now have been found to be black.

(g) Logic is useless because men who know Logic fail in examination.

(h) If a little economy would save half of our expenses, a still greater economy would certainly save all.

(i) June will be the hottest month this year, because it was so last year.

(j) Mercury in the barometer is the cause of changes in whether, because the greater the fall of mercury the greater the disturbance of weather.

(k) Arsenic causes death because it has a mortal quality.

(l) Countenance of slavery was the cause of the collapse of Greek civilization.

(m) The whole family has been vaccinated yet some have had small pox. It is clear, therefore, that vaccination is no safeguard.

(n) There is no use trying for any thing for what is fated must happen.

(o) I do not consult physicians for those that do so also die.

(p) A farmer found that his orchard had been robbed. He borrowed for two nights a dog from a neighbouring cottager, and found each morning that his orchard had been robbed again; he then procured a dog from a distance and found that no further depredations took place. He inferred that the cottager had been concerned in the theft.

(q) All great generals have been remarkable for the excellence of their commissariat; generals who have failed have not been successful in this respect. Therefore attention to commissariat is an indispensable function of a successful general.

(r) Russian and Polish aliens must displace English labour in London, for they do not become chargeable to the rates as would otherwise be the case.

(s) The True, the Good and the Beautiful are inseparable.

(t) The blockade of Germany was the cause of the downfall of that country in the great world war.

(u) Plato says that the circular orbits of the heavenly bodies must be the work of a good God because circular motion is the best.